HD1761
G6
#260

Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

ECONOMIES OF SCALE IN BEEF SLAUGHTER PLANTS

Samuel H. Logan and Gordon A. King

UNIVERSITY OF CALIFORNIA
DAVIS
JAN 31 1963
LIBRARY

CALIFORNIA AGRICULTURAL EXPERIMENT STATION
GIANNINI FOUNDATION OF AGRICULTURAL ECONOMICS

Giannini Foundation Research Report No. 260 December 1962

FOREWORD

This study of the long-run cost function for specialized beef slaughter plants is one phase of work being carried out by the California Agricultural Experiment Station under Western Regional Marketing Research, Project Number WM-37. The project is concerned with the economics of transportation of livestock and meats in the western region, relating to various factors that affect the location of beef cattle feeding and slaughter. Reports on preceding studies have been published on the supply and distribution patterns for feed, economies of scale in large commercial feedlots, and a spatial equilibrium analysis of the location of cattle feeding operations. Other reports are contemplated in this general area. The present study will provide the basis for a second report on factors affecting the location of slaughter plants within California and in the region.

The authors wish to express their appreciation to the excellent cooperation received from the California slaughtering concerns that provided much valuable information in addition to providing access to their plants for time studies; to the Allbright-Nell Co., Chicago, and the LeFiell Co., San Francisco, who provided detailed data on equipment requirements and costs; and to H. H. Olson, Los Angeles architect, for his help in deriving building specifications. Finally, thanks go to Professor R. G. Bressler of the Department of Agricultural Economics, University of California, Berkeley, for his valuable assistance on research procedures and constructive criticism during all phases of the project, and to Dr. A. W. Brant, Department of Food Science and Technology, University of California, Davis, for reviewing the material presented.

TABLE OF CONTENTS

Page

INTRODUCTION 1

General Considerations 1
Objectives of the Study. 5

THEORETICAL FRAMEWORK. 7

The Nature of Plant Operations 8
Short-Run Cost Functions 10
The Long-Run Cost Function 14

METHOD OF ANALYSIS 16

General Approach 16
Procedure. 18

LABOR REQUIREMENTS AND COSTS 21

Description of Plant Operations. 22
Labor Requirements for Killing and Dressing -- Conventional Plants. 26
Labor Requirements for Killing and Dressing -- On-The-Rail Plants. 36
Labor Requirements for Cooler, Dock, Maintenance, Yard, and Clean-Up Work 37
Office, Buying, and Selling Personnel. 42
Management Personnel 44
Labor Costs -- Union Workers 44
Labor Costs -- Non-Union Personnel 49
Total Labor Costs. 51

INVESTMENT COSTS 55

Investment in Model Plants 55
Annual Costs of Investment 73

COSTS OF UTILITIES, MISCELLANEOUS SUPPLIES AND SERVICES. 80

Utilities. 80
Miscellaneous Supplies, Services 89

TOTAL COSTS AND AVERAGE COST FUNCTION. 95

Short-Run Cost Functions 96
Long-Run Costs 96

COSTS WITH SEASONAL VARIATION IN SLAUGHTER 104

Seasonal Variation in Slaughter. 104
Plant Costs with Seasonal Variation. 108

SUMMARY AND CONCLUSIONS. 113

APPENDIX TABLES. 116

LIST OF TABLES

Table		Page
1	Number of Specialized and Diversified Livestock Slaughter Plants, 1955 and 1960, California and United States	3
2	Number of Livestock Slaughter Plants, by Size, 1955 and 1960, California and United States	3
3	Time Requirements and Production Capacities of Workers for Specific Conventional Slaughtering Operations	28
4	Synthesized Crew Sizes for One-Bed Plants with Varying Rates of Output	33
5	Synthesized Crews for Cooler, Dock, Maintenance, Yard, and Clean-Up Work	39
6	Cleaning Time Requirements for Synthesized Plants	41
7	Synthesized Salaried Personnel Requirements for Varying Rates of Output	43
8	Kill Crew Annual Labor Cost in One-Bed Plant for Various Rates of Output	48
9	Total Annual Union Labor Costs for Synthesized Plants	52
10	Total Salaried and Combined Labor Costs for Synthesized Plants	53
11	Costs per Square Foot of Constructing Cattle Slaughtering Plants.	60
12	Building Requirements and Costs for Conventional Plants . . .	61
13	Building Requirements and Costs for On-The-Rail Plants. . . .	62
14	Cost of Corrals and Corral Fencing.	64
15	Cost of Land Areas for Synthesized Plants	67
16	Equipment and Depreciation Costs for Synthesized Plants . . .	72
17	Building Costs and Annual Depreciation for Synthesized Slaughter Plants.	75
18	Annual Personal Property Tax Costs for Synthesized Plants . .	78
19	Charges for Interest and Insurance on Investment for Synthesized Plants.	79
20	Annual Electrical Requirements and Costs for Synthesized Plants.	84
21	Annual Water Requirements and Costs for Synthesized Plants. .	86
22	Annual Gas Requirements and Costs and Total Utility Costs for Synthesized Plants.	88
23	Estimated Functional Coefficients Between Various Costs and Yearly Output	90

LIST OF TABLES (continued)

Table — Page

24 Miscellaneous Costs Associated with Various Rates of Output. 92

25 Estimated Short-Run Costs for Three Synthesized Plants. . . 97

26 Estimated Long-Run Costs of Synthesized Plants. 102

27 Seasonal Patterns of Slaughtering and Marketing of Cattle and Calves in California. 106

28 Seasonal Patterns of Slaughtering in Various Areas of California, 1950-60 107

29 Costs Associated with Reduced Output Resulting from Seasonality of Cattle Slaughter 111

LIST OF FIGURES

Figure Page

1 Source of Beef Slaughter Animals in California and Seasonal Variation in Supplies 4

2 Short-Run Total Cost and Average Cost Functions with Discontinuous Steps. 13

3 Total Cost in Relation to Time of Plant Operation and Rate of Production 15

4 Total Annual Costs of Labor for Synthesized Conventional Plants 54

5 Architectural Floor Plan for On-The-Rail Plants Killing 120 Head per Hour. 62

6 Architectural Floor Plan for Two-Bed Cattle Slaughtering Plant. 63

7 A. Annual Electricity Requirements as a Function of Yearly Output 82
B. Annual Water Requirements as a Function of Yearly Output 82

8 Annual Costs of Miscellaneous Categories as Functions of Yearly Output. 91

9 Short-Run Total and Average Cost Functions for Synthesized Conventional One-Bed Plant 98

10 Short-Run Total and Average Cost Functions for Synthesized Two-Bed Plant. 99

11 Short-Run Total and Average Cost Functions for Synthesized Conventional Three-Bed Plant 100

12 Envelope Curve to the Long-Run Average Cost Points for the Eight Synthesized Plants 103

13 Changes in the Levels of Long-Run Average Costs Caused by Seasonality of Slaughter 112

ECONOMIES OF SCALE IN BEEF SLAUGHTER PLANTS

by

Samuel H. Logan[1] and Gordon A. King[2]

INTRODUCTION

General Considerations

The beef packing industry in California, composed mainly of independent packers, is faced with making adjustments to changing economic conditions. Plants that were built many years ago no longer provide the most economic size of plant for slaughtering operations. Introduction of new technology, such as on-the-rail dressing operations, raises questions as to the cost advantages associated with such plants as compared with conventional plants. Packers must decide whether to re-design the old plant or to build a new plant. These questions prompted analysis of the costs associated with plants of various sizes and technologies of production. This information is designed to provide information to the industry in planning future adjustments, and thus to provide a more efficient livestock slaughter industry in the state.

Plants in California and the United States have become more specialized as to species slaughtered in recent years. In California, specialized cattle and calf slaughter plants increased in number from 22 in 1955 to 26 in 1960, whereas diversified plants decreased from 109 to 91 (see Table 1). Cattle slaughtering plants, of particular interest in this study, tend to be specialized to a greater extent than do plants for other species. Diversified plants appear to be of considerable importance in California and nationally.[1]

---

[1] Assistant Professor of Agricultural Economics, Assistant Economist in the Experiment Station and on the Giannini Foundation, University of California, Davis.

[2] Associate Professor of Agricultural Economics, Associate Economist in the Experiment Station and on the Giannini Foundation, University of California, Davis.

The number of plants in California slaughtering 300,000 pounds or more liveweight annually decreased from 131 in 1955 to 118 in 1960, as is shown in Table 2. The decrease was mainly in medium-sized plants, or those slaughtering between 300,000 and 2,000,000 pounds liveweight annually. Thus, the average volume per plant has increased over this period.[2]

Beef animals slaughtered in California are obtained from three sources: (1) marketings from California feedlots, (2) inshipments of animals for immediate slaughter, and (3) culled animals from beef and dairy herds and grass-fat animals. Marketings from California feedlots have become relatively more important as a source of slaughter animals (see Figure 1, Section A), and in 1961 accounted for 57 percent of the total number of cattle and calves slaughtered. Inshipments of cattle and calves for immediate slaughter have decreased both in absolute and relative importance. The level of inshipments for immediate slaughter, which equalled 739,000 head in 1953, has declined each year since 1956, and totalled 375,000 in 1961. Arizona, the primary source of inshipments, accounted for 70 percent of inshipments in 1961. Culled animals from beef and dairy herds and grass-fat animals also have decreased in relative and absolute importance over this period.

Another dimension of the problem facing beef packers in California is the seasonal variation in supplies. The variation in total numbers of animals slaughtered is much less pronounced than for the three components of supply, as illustrated in Figure 1, Section B. However, packers are faced with the

---

[1] The volume of beef slaughter in specialized vs. diversified plants is not available. A picture of livestock slaughter in California may be obtained from the number of livestock slaughtered and the dependence on inshipped animals for immediate slaughter. The total number of livestock slaughtered in California in 1961 is as follows: Cattle, 2.5 million; calves, 0.4 million; sheep and lambs, 2.5 million; and hogs, 1.6 million. The number of livestock shipped into the state for immediate slaughter is as follows: Cattle and calves, 0.4 million; sheep and lambs, 0.9 million; and hogs and pigs for all purposes, 1.3 million. These data for various years are reported in California Crop and Livestock Reporting Service, California Annual Livestock Report, Summary for 1961. Sacramento, 1962.

[2] Data are not available as to the number of plants classified as to production capacity in each period.

TABLE 1

Number of Specialized and Diversified Livestock Slaughter Plants, 1955 and 1960, California and United States

Item	California		United States	
	1955	1960	1955	1960
Specialized plants:				
Cattle and calves	22	26	518	513
Hogs	--	1	138	165
Sheep and lambs	--	--	5	9
TOTAL	22	27	661	687
Diversified plants:				
Cattle, hogs, sheep	83	60	954	962
Cattle, hogs	5	7	1,334	1,251
Cattle, sheep	21	24	265	241
Hogs, sheep	--	--	3	3
TOTAL	109	91	2,556	2,457
TOTAL	131	118	3,217	3,144

Source: U S Agricultural Marketing Service, Number of Livestock Slaughter Plants, March 1, 1960, Mt. An. 1-2-2 (60) Washington. Includes all plants with an output of 300,000 pounds or more liveweight annually.

TABLE 2

Number of Livestock Slaughter Plants, by Size, 1955 and 1960, California and United States a/

Plants	California		United States	
	1955	1960	1955	1960
Under federal inspection:	56	59	455	530
Other commercial:				
Large b/	53	48	952	902
Medium c/	22	11	1,810	1,712
TOTAL	131	118	3,217	3,144

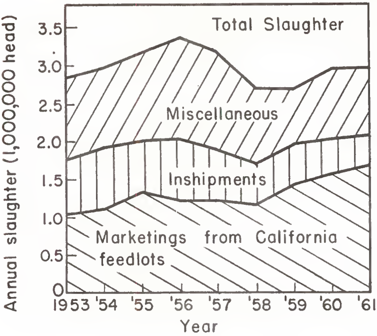
a/ Includes all plants with an annual output of 300,000 pounds or more liveweight annually.

b/ Plants which slaughter over 2 million pounds liveweight annually.

c/ Plants which slaughter between 300,000 pounds and 2 million pounds liveweight annually.

Source: U. S. Agricultural Marketing Service, Number of Livestock Slaughter Plants, op. cit.

Section A: Source of Beef Slaughter Animals



Section B: Seasonal Variation in Supplies, 1953-60

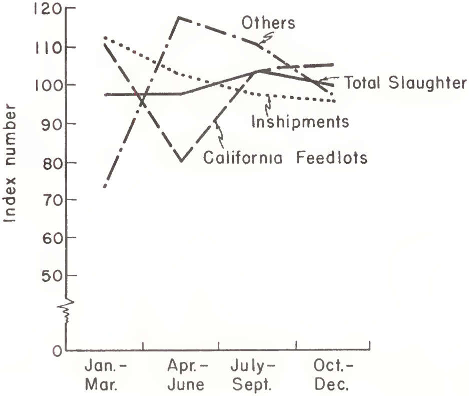


Figure 1. Source of Beef Slaughter Animals in California and Seasonal Variation in Supplies

problem of meeting peak slaughter volumes at certain times of the year and operating at less than capacity at other seasons. Packers have engaged in custom feeding of cattle in feedlots as one means of being assured of a given volume of cattle for slaughter. Future growth of the beef packing industry thus is tied in to some extent with the location of the feeding industry.

The growth of specialized cattle slaughtering in the state as well as the increase in size of plant makes the problem of optimum size and technology of beef slaughtering plants of particular relevance. At present, the size of cattle slaughtering plants in the state is highly varied. Daily kill in specialized beef plants studied ranged from 75 to 450 head. Cost levels in this study apply to the Los Angeles area, a major slaughter area of the state. However, costs for other areas may be readily applied to the relationships derived.

Objectives of the Study

The major objective of this study is to determine the nature of the long-run average cost curve for specialized beef slaughtering plants. Here, emphasis is placed on changes in cost per head slaughtered associated with changes in the size of scale of plant. There are two questions that must be answered: (1) For a given level of output, what technology of plant will provide the least-cost slaughtering and (2) how does the level of costs vary with the size of plant?

The answers to these questions are important to persons in the slaughter industry, especially in planning for the construction of new plants or the remodeling of existing plants. Thus, for a given demand for beef, the firm can determine long-run scale that will maximize profits.1/

1/ Under pure competition in both selling and buying markets, the optimum scale would be where average cost is at a minimum (see Stigler, G. J., The Theory of Price, New York: The MacMillan Co., 1949, page 160). Under imperfect competition profits would be maximized where marginal cost equals marginal revenue (see Chamberlin, E. H., The Theory of Monopolistic Competition, Cambridge: Harvard University Press, 1960, page 77).

This study provides data on physical input requirements as to labor, buildings, equipment and related inputs such as utilities. Cost applicable to Southern California have been applied to obtain cost functions; however, the form of the relationships allows use by other areas within the state and in other regions of the country by applying relevant cost levels for those particular areas, such as wage rates, building costs, and utility costs.

In addition to the answers to the above questions, answers to questions both of a supplementary and complementary nature will be sought. These are: (1) How will average costs per head slaughtered vary if the plant is operated at, say, 70 percent of capacity, as compared with 100 percent of capacity and (2) how do costs of slaughtering vary as the supply of animals changes because of seasonal factors?

A plant manager is often faced with the problem as to whether the plant should be operated at maximum capacity or to cut back production because of certain demand conditions or because of the necessity of purchasing cattle at unfavorable prices or at locations which involve higher transportation costs. This study provides the cost of plant operations necessary to obtain answers to the above problems. However, certain important institutional factors are not considered such as the necessity of providing a fairly constant supply of carcass beef to assure good relations with purchasers.

This study is limited to the analysis of slaughtering operations under two major technologies -- a conventional or bed-type slaughter and the more automated on-the-rail dressing system.1/ It does not consider other aspects of the meat packing business that are found in many operating plants such as rendering inedible by-products, curing hides, operating sausage kitchens, or breaking carcasses into the various cuts of meat. Possible economies due to the horizontal integration of such operations with cattle slaughtering were considered as beyond the scope of this study. However, the effects, if any,

---

1/ These two technologies are described in detail in a later section.

of such integration on the results of this analysis, a priori would be expected to reduce the estimated costs of slaughtering because of the joint use by slaughtering and the other operations of certain facilities -- buildings, utility fixtures, management -- which in this study are used solely for slaughtering. Total costs, however, would increase with the additional requirements for labor, equipment, and other inputs used in the associated, but non-slaughtering, operations.

THEORETICAL FRAMEWORK

The study of economies of scale is basically the study of the nature of the long-run cost function facing the firm. Such a cost function, representing the lowest cost of production for various levels of output, is applicable when all factors of production used by the firm are allowed to vary. In other words, the producer or firm in the long-run can change technologies and alter the capacity or scale of his plant; there are no fixed factors. The assumption of variability of all factors is the major dividing line between long-run functions and short-run functions. In the latter case, the scale of plant is regarded as constant.

Capacity may be considered either technically or economically. Technical capacity in this case refers to the maximum rate of output possible for the plant regardless of costs, and is bounded by the technical nature of the plant and equipment. The economic capacity indicates the least average cost point of operation.1/ Capacity or size in the cost-volume relationships will be assumed to be one of economically efficient output for a plant operating one eight-hour shift per day as opposed to maximum technical output.

The reasoning behind the nature of the long-run cost function has been explained by many authors.2/ Such explanations usually define the long-run

---

1/ Dean, Joel, The Long-Run Behavior of Costs in a Chain of Shoe Stores: A Statistical Analysis, Chicago: University of Chicago Press, 1942, page 6.

2/ See, for example, Viner, Jacob, "Cost Curves and Supply Curves," Zeitschrift fur Nationalokonomie, III, 1931, pp. 23-46, reprinted in A.E.A., Readings in Price Theory, London: George Allen and Unwin, Ltd., 1956, pp. 198-232. Also see Stigler, George, The Theory of Price, New York: The MacMillan Co., 1949, Chapter 8.

function as an "envelope" curve to a series of short-run cost functions for each of which the plant size is fixed.[1] The envelope, which represents the points of tangency for an infinite number of short-run cost functions or a scallop of a limited number of short-run functions, does not necessarily pass through the lowest cost point on the short-run average cost function.[2] Depending on the nature of the series of short-run functions, the long-run average cost curve may exhibit constant returns (constant costs per unit of output), increasing returns (decreasing costs per unit), or decreasing returns to scale (increasing costs per unit) or combinations of them.

This study relates to a single plant firm producing one product under conditions of perfect competition. The major considerations in constructing a theoretical model for appraisal of economies of scale of beef slaughtering plants include: (1) the nature of plant operations; (2) the cost function for a plant of given scale and technology of production with consideration of the nature of factor substitution, the possible discontinuities in the related cost functions, and the relevant cost function when output is varied in both the time and rate dimensions; and (3) the long-run cost function with varying scale of output and related alternative production technologies.[3]

The Nature of Plant Operations

Certain characteristics in plant operations apply to a wide variety of products, the basic one of which is the transformation of the form of the intermediate product or products into a final product or a good that itself is an intermediate product in further production processes. It is convenient to consider the product moving through various stages of production, where each stage is involved in performing some separate production operation. These stages may be independent of each other with each stage having its own separate cost function, or they may be interdependent. For example, workers in one stage may also be used to handle operations in another stage. For a given level of output, the goal of efficient organization of inputs of labor and machinery is to obtain this output at minimum cost. Thus, when the various stages of operation have separate cost functions, the total cost function becomes the sum of the functions of the individual stages. In this manner, the minimum cost for total output may not fall at the minimum cost point on the individual stage functions. Multiples of the various stages may be required, then, to co-ordinate all the production stages into a harmonious whole.

---

[1] See later discussion on the economies of scale curve as an envelope to a series of cost functions utilizing different technologies.

[2] See Viner, "Supplementary Note," Readings in Price Theory, op. cit.

[3] A reformulation of the theory of the firm has been made by French, B. C., L. L. Sammet, and R. G. Bressler, Jr., in "Economic Efficiency in Plant Operations with Special References to the Marketing of California Pears," Hilgardia, Vol. 24, No. 19, Berkeley: University of California, July 1956, pp. 548-579. Many of the theoretical constructs used in this study draw upon their work.

With several stages of operation in a processing line, a variety of production capacities is often found at the different processing points. The lowest capacity rate, then, may become a bottleneck or a limit on the total production of the plant and the other stages may exhibit excess capacity. Such bottlenecks may take the form of the maximum output possible from a machine or the maximum production for a given labor crew. The nature of the slaughtering operation is such that in some operations, such as removing the hide, only a limited number of men can be assigned to the job at any one time.

In determining the output of a particular plant, it is often possible to change the rate of production by changing the number of workers employed in certain production activities (in the short-run) by adding a completely separate processing line which essentially replicates the operations of the first line (in the long-run), or by shifting to alternative technologies.

A second dimension of output, other than the rate dimension mentioned above, is the time of operation. The distinction between changes in the time and rate dimensions must be made to define the relevant cost functions. The importance of the time dimension varies among types of processing operations. For example, in seasonally produced crops that are processed, much variation is possible in the number of hours that the processing plant is operated per season. In beef slaughtering operations, however, it is more usual to have a flow of animals for slaughter all during the year. Thus it is common that the plant will operate all 52 weeks of the year. However, because of seasonal changes in demand and/or supply of cattle, the rate of slaughter may change. Also, it is possible to have multiple shifts of workers, each employed eight hours per day. In this study, however, the major emphasis is placed on the rate dimension of output.

Short-Run Cost Functions

In estimating the short-run cost curve, the scale of plant -- determined by the quantity of fixed resources -- sets the maximum amount that can be produced in a given time period. With a given plant, the problem becomes one of finding the optimum combination of variable factors to employ for various levels of output. For a firm that maximizes profits, the short-run solution requires determination of that output at which marginal cost equals marginal revenue, assuming smooth, continuous cost and demand functions.1/ This output level is always the same whether fixed costs (that is, the costs associated with the flow of services from the land, buildings, equipment, and so on) are included or not.2/ From the view of determining the long-run economies of scale curve, however, these fixed costs become variable and must be included. As was mentioned previously, the long-run cost function is the envelope to the short-run cost curves for which the scale of plant is fixed. These fixed cost elements must be met in the long-run operation of the plant.

The short-run and long-run average cost functions traditionally are presented as smooth, continuous curves decreasing as output increases and

---

1/ Marginal cost and marginal revenue are defined as being the first derivatives of the total cost function and the total revenue function respectively, with respect to output. In other words, marginal cost is the change in cost associated with a small change in output, whereas marginal revenue is the change in total revenue associated with a small change in output.

2/ A certain amount of the fixed cost of depreciation is of a variable nature depending upon the amount of usage of the equipment. In addition, there are certain other fixed costs such as management salaries which must be covered in the short-run if the plant is to remain in operation. In general, however, the fixed costs are not relevant in determining the level of operation of a profit maximizing firm in the short-run.

then, in the case of the short-run function, turning upward at some point of larger production. Such treatment implicitly specified several conditions: an infinite number of plants in the short-run, perfect divisibility of inputs, and perfect competition in the factor market. Also, the conventional theory is generally concerned with expansion of output by altering the rate of output per unit of time.

As described above, however, the nature of many processing plants is such that many of these conditions do not exist. These "imperfections" must be fused into the theoretical model in order to set up the relevant dimensions of the empirical analysis.

Factor Substitution and Intensification

In the short-run, given a particular technology, the slaughtering firm is faced with a situation of using variable factors of production in nearly fixed proportions. Inasmuch as the equipment is fixed in the short-run, the basic substitution possibility is between labor and other variable inputs; however, the functions performed by labor and other inputs are basically separate and supplementary rather than substitutable. Hence, shrouds, knives, utilities, and such cannot be substituted for labor inputs without an accompanying reduction in output. In addition, institutional factors such as union contracts restrict possible substitution involving labor during time periods for which wages are guaranteed. Such factors will be discussed later.

Under this situation, the major alteration in inputs becomes one of intensification on the fixed factor in an effort to increase production. When output, however, is limited by the capacity of an input or group of inputs as described previously, the average cost function assumes a different shape from the conventional function which shows costs gradually increasing. At the point where the production capacity of the bottleneck is attained, the short-run average cost function may be presumed to turn up sharply as the output is effectively halted for that size of plant no matter how many more inputs are added.

Discontinuities

While short-and long-run cost functions are generally represented by continuous curves, in reality cost functions often exhibit discontinuities. Such discontinuities generally result from indivisibilities of factors of production. In other words, inputs are added by discrete units instead of as a continuous flow. For example, the short-run addition of a unit of labor may cause costs to jump by a set amount (unless the worker is paid piece-rate on his production), but output may vary almost continuously over a considerable range as a result of the extra unit of input. Such a jump may occur because of the discrete nature of the input or because institutional factors such as union contracts require a guarantee of a 40-hour week for laborers no matter what the time worked nor the amount of output.1/ Hence, the discrete increase in cost which then remains constant over a range of production yields a total cost function with a stair-step nature (see Figure 2). The average cost function then takes on a jagged appearance.

Profit maximization which under the conventional theory occurs when marginal cost equals marginal revenue (or price in perfect competition) in this case may become a corner solution which cannot be derived by calculus and algebraic equations.2/ In this case, the plant would operate at the peak output of one "step" on the total cost function rather than jumping a discrete amount to the lower output range of the next higher step.

Time and Rate Dimensions of Production

Usually, the cost-volume relations are considered in the rate sense, that is, the rate of production per unit of time is expanded while the time unit is held constant. In many production operations such as cattle slaughtering, output is also changed in a time sense. If the basic rate period, for example, is one hour, then production may be carried on for

---

1/ Union contracts and institutional influences will be discussed in a later section dealing with labor costs.

2/ For a demonstration of profit maximization under the "corner solution", see French, Sammet, Bressler, op. cit., page 554.

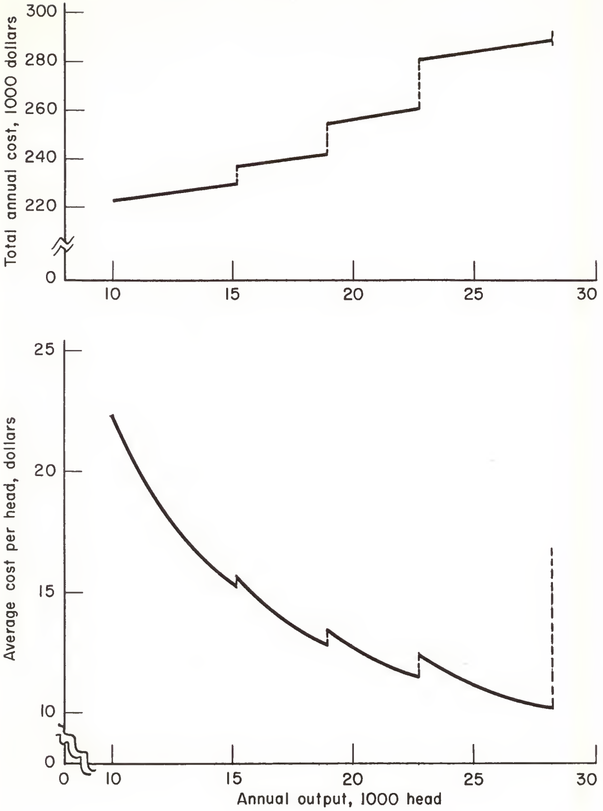


Figure 2. Short-Run Total Cost and Average Cost Functions with Discontinuous Steps

an eight-hour period, with each period being a multiple of a one-hour unit. Or the basic production period may be an eight-hour work day which can be expanded into three shifts per day. Again institutional factors such as labor contracts may make the relevant cost period a forty-hour week with annual output and costs being a multiple of the weekly period.

Given constant per unit costs of the inputs, then the costs of operating at some multiple level of the basic time unit are simply a linear projection of the original unit. A three dimensional diagram (see Figure 3) presented by French, Sammet, and Bressler illustrates total operating cost as a function both of rate of output and of time of production.[1] The flat base of the diagram represents the fixed costs facing the firm in the short-run. The T axis shows the cost of expanding the time of production where t_1 is the basic time unit. Thus, the trace of the cost surface for t_1 is the traditional textbook cost function which assumes output over a certain time period, t_1. As the rate of output is expanded from x_a through x_e, costs follow the pattern shown by the trace through t_1. If, on the other hand, the rate of output is held fixed at say x_b, but the number of time units worked is increased, then costs follow the linear pattern shown by the trace through x_b.

Certain institutional factors may alter the linear nature of costs in relation to time of production. For instance, many butcher union contracts in California call for increased wages for all work over eight hours a day. In this manner, the linear cost function (output expanded through time) may exhibit a kink or discontinuity as costs suddenly increase at a faster rate upon the completion of a "normal" work period. Similar discontinuities may arise for premium payments given employees working on night shifts.

The Long-Run Cost Function

The long-run planning curve may similarly depart from a smooth, continuous nature and have a jagged appearance because of expansion by

---

[1] French, Sammet, and Bressler, op. cit., page 573.

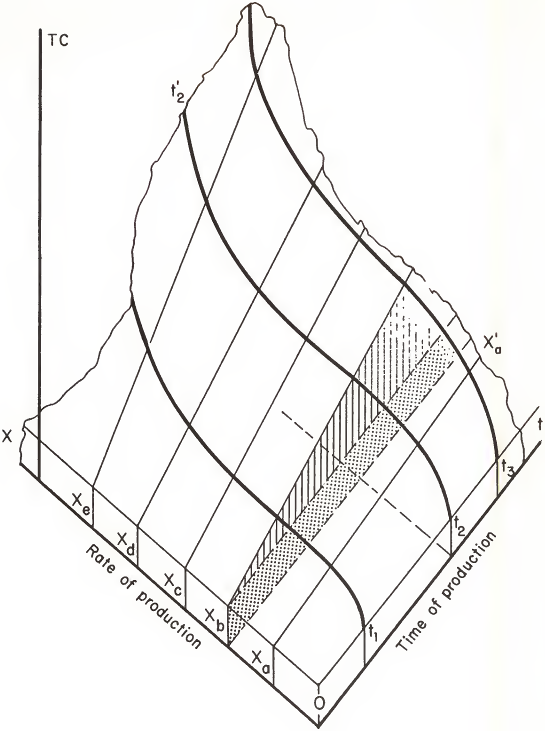


Figure 3. Total Cost in Relation to Time of Plant Operation and Rate of Production

segmentation, or the indivisibility of factors added in the long-run. In cattle slaughtering plants, expansion under one technology is achieved by adding a complete new processing line. Thus the cost of expansion (for the new line) will remain constant although the rate of production over this new line may vary considerably. As a consequence, the total cost function takes on a stair-step nature.

In summary, where kinks and discontinuities result from capacity limitations and indivisibilities of factors, the cost function cannot be described by a smooth, continuous algebraic equation. When coupled with the three dimensional concept of cost as a function of both rate and time of production, the latter modifications result in a model in which total costs may be discontinuous in the rate sense, while exhibiting kinks in the time dimension.

In the long-run several technologies may be available for the production of the good in question. Each technology in this case will have an envelope curve to its own series of short-run curves. With several technologies, the long-run planning curve is an "envelope to an envelope", being tangent to the long-run envelope curves for each technology. One technology may exhibit lower average costs over all ranges of output than any other technology, or several technologies may compose the long-run average cost function, each dominating the curve for a small range of production. In such a case, one would expect to find plants utilizing that capacity for a given output which had the lowest average cost.

METHOD OF ANALYSIS

General Approach

The general approach used in determining economies of scale in beef slaughter plants is an economic-engineering type study involving the "synthesis" of long-run cost functions. This approach has become an important tool for analyzing costs in many agricultural studies. Basically, the synthesis approach involves breaking down the production process into its elementary details, obtaining the physical input-output relationships at this level, then with these relationships as "building blocks" synthesizing model plants for various levels of output. By converting the physical relationships into cost-volume relations, the long-run cost function is determined. The "building blocks" by which the cost function is synthesized are obtained by various means. Actual physical relationships for labor inputs may be determined through time studies, work sampling studies, or interviews with administrative personnel and/or foremen.[1] Other input-output relationships may be obtained through direct use of accounting data. Finally, equipment manufacturers may be consulted as to equipment costs, capacities, and operating requirements for electricity, gas, etc.

It is generally convenient to consider various stages of plant operations especially in deriving labor requirements. Broadly speaking, slaughtering plants include the following stages of production: yard operations in receiving and feeding of livestock; production operations in killing, dressing of carcasses, and handling by-products; carcass cooling and loading operations; maintenance and clean-up operations; and administrative operations in buying livestock and selling meat. With specified output per time period from various crew organizations, appropriate cost rates for individual workers may be applied to obtain total costs associated with various output levels, production technologies, and plant sizes.

The physical output capacity per hour for a plant is related to the technology employed and to the degree with which the various stages of production may be "harmonized". In slaughtering operations, a plant will exhibit different capacities depending on the degree of specialization and the number of workers used in a particular operation. Capacity output for a given plant then is generally that level of production which is the "common denominator" for the range of capacities of the various stages. That is, there usually will be one operation that will be the limiting factor for further expansion of output. For example, in the conventional bed-type slaughter systems, it was found that the rumping and backing operation generally limits the output of the entire production line, a task which is duplicated as new beds are added. After the rumping and backing crew reaches two workers for a one-bed plant, little output can be gained by the use of additional workers in this operation. The nature of the work and the size of the carcass are such that the work area is too small for more than two men -- one working on each side of the animal. Extra workers might even be detrimental to output by imposing a safety hazard of too many knives being used in a small area. Similar limiting operations are found in various other sizes of plants and with various technologies.

---

[1] French, Sammet, Bressler, op. cit., pp. 581-582.

Once the physical capacity of output is determined for a particular technology, it is possible to design a model plant which will correspond to this output. Eight model plants were specified to serve as the basis for study of long-run costs of slaughtering. These plants had designed slaughter capacities per hour of 17, 20, 35, 40, 50, 60, 75, and 120 head of cattle with average liveweight of 1,100 pounds and dressed weight of 600 to 700 pounds per head. The designed capacity of the storage coolers is based on the daily output of the plant, which equals the hourly output multiplied by 7.5 hours.1/ Coolers were designed to have a holding capacity of three days' kill. In developing the cost data, plants were assumed to operate one eight-hour shift a day, five days a week, and 52 weeks per year, with no operation on holidays. This results in 252 days of productive work per year.2/

Procedure

The approach used in this study involved "constructing" model slaughter plants of varying designed capacities and technologies, and determining the costs associated with operating plants at various levels of capacity. The economies of scale curve then is derived from the short-run cost curves associated with the individual plants. The procedure used in developing physical relationships and costs may be summarized as follows:

1/ The figure of 7.5 hours per day allows fifteen minutes of rest time in both the morning and afternoon during a regular eight-hour shift.

2/ The bases for these assumptions will become more apparent in discussions in later sections.

I. Specification and "construction" of model plants

  a. Determination of the physical input-output relationships of labor and associated inputs for various stages of production, and the determination of the limiting factors on output for plants under given technologies.

  b. Specification of capacity output for eight model plants and the determination of the investment requirements in a physical sense for plant and equipment.

  c. Determination of the changing input requirements for operating plants at various levels of capacity for such items as labor, utilities, supplies, and management.

II. Estimation of short-run average cost functions

  a. Determination of total costs per year associated with operating each plant at a given level of capacity by applying appropriate cost rates to the physical input data developed previously. Exceptions to this procedure will be noted.

  b. Calculation for each model plant of the average cost per head slaughtered when the plant is operated at various levels of designed capacity.

III. Determination of the long-run average cost function, or the "economies of scale" curve by fitting an envelope to the short-run cost curves of the model plants.

In developing the average cost functions for the model plants, the specification was introduced that plants would operate at a given level of capacity uniformly throughout the period under consideration, which was one year. The effect on costs of seasonal variation in the supply of slaughter animals is considered as a separate problem in this report.

Slaughtering was analyzed under two major types of technology. Many of the operations are identical under each system and the end products are, of course, the same. The means of producing the dressed carcass are decidedly different, as will be explained in detail later. One system, designated as a "single rail, conventional bed-type" method involves more handling of the carcass by the worker than does the more mechanized system known as "on-the-rail dressing".

Sources of data used in this study include: (1) in-plant time studies of labor time requirements for various operations; (2) accounting data from plants studies; (3) a supplementary survey of labor specifications in plants operating in California; (4) plant and equipment specifications and costs from engineering and construction firms; and (5) labor wage rates, applicable to the Los Angeles area for 1960, from union wage contracts. The use of these data will be explained in detail in this report.

Labor requirements were obtained from in-plant studies of eight California beef slaughtering plants. Daily output ranged from 75 head to 450 head under actual operating conditions. Studies were made on the time required for the carcass to pass through the various operations on the killing floor under different crew sizes. These time requirements allowed estimation of the capacities of the individual workers or crews (in terms of head of cattle per hour) for the various jobs. In deriving capacities of the workers in specified operations, a level of output was desired that could be maintained by the worker consistently over the eight-hour work period (allowing one-half hour for rest breaks). Generally, the observations on the same operations staffed by the same number of workers in the various plants with the same technology were similar. Therefore, an average of the time requirements in all plants was used as the basis of estimating employee output capacity in each work task. The estimated capacities were then used to specify labor crews in production operations for the model plants. A lack of plants slaughtering under the on-the-rail method in California required the use of manufacturers' labor specifications which similarly were based on time studies. Other labor positions, including office and management personnel, were synthesized from observations of actual plant operations and from requirements reported in other studies.

Investment costs were synthesized in order to obtain uniform construction materials and standarized costs of depreciation, insurance on equipment, interest on investment, and personal property taxes for all of the model plants. Thus, the changes in investment costs among model plants would result solely from size factors rather than being confounded by non-size factors. Actual costs of operating plants would reflect such factors as depreciation policy, age of plant, and location within the state.

Utility costs were developed for electricity, water, and gas. For electricity, estimates for each of the model plants were based on a regression analysis of monthly and yearly physical consumption data obtained from the sample of slaughter plants. Estimates of water requirements were made directly from accounting data on average consumption of water for the sample plants. This procedure was due to insufficient data on variation in water consumption associated directly with variation in the level of slaughtering. Consumption of natural gas as fuel, on the other hand, was synthesized by specifying the fuel needed to operate various sizes of boilers and applying appropriate cost rates to consumption levels.

Miscellaneous costs, such as repair, maintenance, killing supplies, office supplies, and the like do not exhibit physical relationships to output that may be synthesized readily. In such cases, regression analysis of accounting data or simple averages of accounting data were used.

LABOR REQUIREMENTS AND COSTS

Two major types of technology are found in cattle slaughtering plants: (1) the conventional bed-type system, and (2) the more automated "on-the-rail dressing" system.1/ These differ mainly in the dressing operation with other operations such as cooler and dock loading tasks identical under both. In California and much of the western coastal region, conventional slaughtering is predominant although the on-the-rail systems are being considered for new plants. Manufacturers of the on-the-rail equipment currently are located in the midwest where most plants using this system are found.

A general description of the various operations in cattle slaughter is given for conventional plants with differences noted in the dressing operation under the alternative technology. The development of labor requirements for slaughter plants is then described, followed by the estimation

---

1/ Floor plans are shown in the section on Investment Costs which indicate the major stages of processing under the two technologies.

of labor costs for the conventional model plants operated at various levels of daily capacity, and for the on-the-rail plants operated at capacity. Lack of observations on the more automated method of slaughter precluded estimation of short-run cost curves.

Description of Plant Operations

Conventional Bed-Type Plants

A supply of animals for one or two days' slaughter is kept in holding pens located adjacent to the plant. Animals are then driven as needed into the knocking pen (or pens), a small enclosure, open from above. A worker, known as a knocker, stuns or kills the animal in the pen. A large door on the side of the pen allows the carcass to slide onto a "dry landing area," where it is shackled around one or both hind legs and hoisted mechanically to the bleeding rail, 16 feet above the floor.[1] A "sticker" severs the cartoid artery in the neck allowing the blood to drain from the carcass. While the carcass is still suspended over the bleeding area, the hide is trimmed from the face, and the head is disjointed from the body. A head washer then removes the head, washes it thoroughly, and places it on a rack to await removal of the tongue, cheek meat, and brains by the head trimmers.

From the bleeding area, the carcass is lowered to either a cradle -- two parallel bars which hold the carcass on its back about six or eight inches off the floor -- or to pritch plates which are simply large metal plates in the floor. In the latter case the animal is propped up on its back by a metal rod, or pritch bar. In this position, the legs are cut off, the hide is removed from the sides of the animal, and the brisket bone is split. The hooves either are placed in barrels which are periodically transported to a storage dock area, or are thrown down a chute to the dock area from which they are picked up by a rendering company.

---

[1] U. S. Department of Agriculture-Agricultural Research Service, U. S. Inspected Meat Packing Plants. A Guide to Construction, Equipment, Layout, Washington, D.C., Agricultural Handbook No. 191, 1961, page 19.

Following the legging and siding, hooks on a round trolley are inserted through the gams (between the large tendon and the bone) of the hind legs; the trolleys are placed on a hoisting tree; and the carcass is raised to a position with its rump about waist high. The rumper and backer then skin the hide away from the flanks of the animal and from the tail. The animal then is hoisted completely off the ground, a paunch or guts truck is pushed under it, and a "gutter" eviscerates the animal. In small plants the gutter also serves as a "trucker" taking the viscera in a paunch truck to a federal inspector for inspection and then to a tripe table where it is separated.1/ The offal -- lungs, heart and liver -- are taken to another worker who washes and separates this material.

Upon completion of the rumping, backing, and gutting, the carcass is lifted to the rail where the hoisting tree is released, and the carcass is suspended on the rail by the trolleys. The hide is then fully removed by the hide dropper and is placed in barrels or dropped through a hide chute either to a hide cellar for curing or to a shipping dock for direct pick-up.

The carcass is then ready to be split. In most California plants, this operation is done by a worker (splitter) standing on a hydraulic lift platform who cuts through the animal's spine with a power saw. Following the splitting, a small saw is pulled down the exposed inside portion of the backbone, and the top side of the backbone is broken away from the lower portion. (This function is known as scribing.) The two sides, or halves, of the carcass are then washed thoroughly to remove blood and bone scraps and are weighed. Wet cloth shrouds -- generally made of cotton -- are then pinned on the halves to give the carcass a better, smoother appearance after cooling and to prevent drying. The animal is then pushed to the

---

1/ Labor costs for federal inspectors for a regular eight-hour day are paid by the federal government, and therefore are not considered in this study. While costs of federal graders are assumed by the individual firm, their use is strictly voluntary by the firm. For this reason, costs of grading also were not included.

"hot box" or "chill cooler" in which the body heat is removed. The carcass generally remains in this cooler overnight, after which time it is moved to the holding or sales cooler and left for about two days.

The remaining operations of concern to this analysis include removing the shroud from the chilled carcass, assembling the carcasses for shipping orders, pushing them to the loading dock, and finally weighing and loading them on the trucks.

On-The-Rail Dressing Systems[1]

Stated simply, on-the-rail dressing means that all the processing operations are done while the carcass is suspended on the rail; the animal

---

[1] The on-the-rail systems to be considered in this study are powered systems, i.e., the carcass is moved along the rail by a powered conveyor mechanism. Another on-the-rail system which is classified as a "gravity-flow" system also is available which does not utilize conveyors. In this case, the height of the rail, beginning in the bleeding area, declines as the carcass moves to the various dressing operations. Rail stops at the various operations halt the movement of the carcass for work at that particular area. Thus, the moving of the animal along the rail is caused by the force of gravity rather than mechanical power. Don R. Hammons, industrial engineer with the United States Department of Agriculture and located at Oklahoma State University, has made a study of the relative costs of slaughtering under the powered rail system and under the gravity-flow rail system for a slaughter rate of 24 head per hour of cattle weighing 500-700 pounds. The comparisons were restricted to the line operations on the killing floor only excluding the supporting operations. The labor requirements and costs and equipment costs (all per 100 head of cattle) will be reported in full in a forthcoming publication. Mr. Hammons, in correspondence, kindly provided the following cost estimates:

	Productive time	Cost	Unproductive time	Cost	Total cost
Gravity Rail System					
Labor	41.84	115.06	4.87	13.39	128.45
Equipment					17.92
Total					146.37
Powered Rail System					
Labor	42.83	117.81	3.31	9.10	126.91
Equipment					22.29
Total					149.20

The labor cost was based on a uniform wage rate of $2.75 per hour per worker and the equipment cost was based on a depreciation policy reported by the U.S. Treasury Department, Bureau of Internal Revenue in Bulletin "F", (Revised January 1942) Income Tax Depreciation and Obsolescence Estimated Useful Lives and Depreciation Rates, Washington D.C.: U.S. Government Printing Office, 1948.

On a per-head basis, the costs of the two systems for the same output differ by less than three cents.

is not dropped, then rehoisted to the rail. Two major types of powered rail dressing operations are illustrated by the Bovi-Mation system manufactured by the Allbright-Nell Co., Chicago, and the Can-Pak system developed by Canada Packers, Ltd., Toronto. Although other rail systems are made, it is assumed that they will fall under one of the two above systems.

The Bovi-Mation and Can-Pak systems are similar in many aspects. For smaller kill rates, less than 40 head per hour, the carcasses are carried by an intermittent skinning conveyor, i.e., a powered chain moves the animal along the rail at intermittent time intervals. Larger output generally utilizes a continuous moving skinning conveyor which moves at adjustable speed without stopping. The latter method is also associated with a moving top viscera table. The carcasses move over the table (the top of which moves in accordance with the rail conveyor) and the viscera is removed onto the table where it is inspected and routed to appropriate work-up areas.

Under the Bovi-Mation system, the operations through the removal of the head follow the conventional pattern.[1/] From this point, however, the on-the-rail systems differ significantly from the bed systems as the workers become more specialized. A worker on a high platform skins the free hind leg, saws off the hoof with a portable power saw, rims the bung, and prepares the tail for skinning by the hydraulic tail puller. A second worker, also on a platform, then places a transfer hook in the gam of the free, skinned leg and lifts the carcass with a power hoist attached to the transfer hook. The shackle is then removed the returned by rail to the bleeding area, the second hind leg is skinned, and the hoof removed.

Another worker changes the carcass from the transfer hooks to regular trolley hooks which are engaged on a spreader (the latter holds the legs apart). Additional workers drop the bungs, open the flanks, split the aitch bones, and skin flanks on both sides. The animal then continues along the rail to an operator who skins the rump and tail, disjoints the tail, and trims any high bruises.

[1/] Description of the operation of the Bovi-Mation system is taken from Powered Cattle Dressing on the Rail, Folder No. 83, The Allbright-Nell Co., Chicago.

On the floor level, another worker skins and cuts off front feet, and rods and ties the weasand. Workers on hydraulic lift platforms then rim over the brisket and part of the shoulder, open the brisket with a power saw, and skin the back and shoulders from both sides. The hide is then fully removed.

In smaller operations (40 head per hour or less) evisceration is done at a "drop section" of the rail utilizing paunch trucks. Here the rail is suspended by a hydraulic lift and, not being connected to the regular rail, can move up or down permitting the eviscerator to move the carcass up or down in order to reach into the body cavity for gutting without spilling the weasand or gut contents.

The splitting operation is basically the same as that in the conventional plant except that here the rail is also suspended from a hydraulic lift which lowers the spreader and deposits the trolleys on a run-off spur. On the run-off spur, the scribing, inspection, trimming, washing, and shrouding are performed. The carcass is then weighed and sent to the cooler.

The Can-Pak system is similar to the one just described; however, the carcass is suspended directly from the rail by a heavy duty trolley instead of being carried on a spreader device.1/ The major difference between the Can-Pak and the Bovi-Mation system is the use of a hydraulic hide puller in the former system which performs the siding operation by mechanically pulling the hide from the sides of the carcass. The eviscerating, splitting, shrouding, washing, and scaling are basically the same in both cases.

Labor Requirements for Killing and Dressing -- Conventional Plants

Primary attention was directed in this study in developing time requirements associated with the slaughtering operation. The costs associated with

---

1/ Description of the Can-Pak operations is taken from Cattle and Calf and Sheep Slaughtering Equipment, Catalog No. 101, The Globe Co., pp. 4-9.

this operation account for approximately 65 percent of all union wages for the various plants operated at capacity levels. The time requirements were then used in the specification of crew sizes for the model plants, and in the subsequent development of labor costs.

Time Requirements

In order to determine the number of workers needed to slaughter cattle at varying rates per hour, in-plant studies were made at seven conventional slaughtering plants including 1 one-bed plant, 4 two-bed plants, and 2 three-bed plants. Time studies were taken of the various operations to estimate the capacity in head per hour for various sizes of crews [1] (see Table 3). A time rate was desired that could be maintained over an eight-hour day without becoming detrimental to worker safety and quality of the product. The range of output in the plants studied was from 10 head per hour to 50 head per hour.

The labor requirements were obtained by timing the various crews rather than individual workers in the performance of particular operations. For example, in deriving time requirements for the siding and legging operations, the relevant time was from the lowering of the animal to the floor until the last crew member had completed his task. Inasmuch as crew members who perform certain operations, such as siding and legging, work as a combined unit with some job interchange, determination of time requirements by crews rather than by individual workers, appeared to offer the more meaningful measurement.

Idle employee time -- work time not spent in direct production -- was included in the time requirements since most of this time is spent in cleaning hands, boots, knives and in honing the knives. A certain amount of time occurs in the multiple-bed plants during which no work is performed on the carcass as the crew workers move to another bed, finishing their job before the following work station is ready for the animal. This time is not shown in

---

[1] For a discussion of time study techniques, see French, Sammet, and Bressler, op. cit., page 581.

TABLE 3

Time Requirements and Production Capacities of Workers for Specific Conventional Slaughtering Operations

Operation	Crew size	Average time required per head slaughtered			Production capacity per crew expressed in number of cattle per hour				
		One-bed	Two-bed	Three-bed	One-bed	Two-bed		Three-bed	
						Per bed	Total	Per bed	Total
	no.	minutes			number				
Kill, remove head and wash head:									
Knock, shackle, stick, face, head, wash head	1.0	4.1	4.1	4.1	14.6	[a]	14.6	[a]	14.6
Knock, shackle, stick	1.0	1.5	1.5	1.5	40.0	[a]	40.0	[a]	40.0
Knock, shackle	1.0	1.0	1.0	1.0	60.0	[a]	60.0	[a]	60.0
Face, remove head	1.0	2.1	2.1	2.1	28.6	[a]	28.6	[a]	28.6
Wash head	1.0	.6	.6	.6	100.0	[a]	100.0	[a]	100.0
Remove hide, eviscerate, split and scribe:									
Side, leg	1.5	4.4	[b]	--	13.6	--	--	--	--
	2.0	4.2	--	--	14.3	--	--	--	--
	2.5	--	2.8	--	--	21.4	21.4[c]	--	--
	5.0	--	2.5	--	--	24.0	48.0[d]	--	--
	6.0	--	3.0	2.9	--	20.0	40.0[d]	20.7	51.8[e]
Rump, back, gut	1.5	5.9	--	--	10.2	--	--	--	--
	2.0	4.7	--	--	12.8	--	--	--	--
Rump, back	1.5	--	3.6	--	--	16.7	25.1[f]	--	--
	2.0	--	3.4	--	--	17.6	26.4[f]	--	--
	3.0	--	2.9	--	--	20.7	31.1[f]	--	--
	4.0	--	--	4.2	--	--	--	14.3	42.9[g]
Gut, truck, hang offal	1.0	--	--	--	23.1	[a]	23.1	--	--
Gut only	1.0	--	--	--	--	[a]	35.0	[a]	35.0
Hide drop, split, scribe	1.0	4.5	4.5	--	13.3	[a]	13.3	[a]	--
Hide drop	1.0	--	1.5	1.5	--	[a]	40.0	[a]	40.0
Split	1.0	--	1.3	1.3	--	[a]	46.2	[a]	46.2
Scribe	1.0	--	1.2	1.2	--	[a]	50.0	[a]	50.0
Carcass finishing:									
Wash, scale, shroud	1.0	5.0	--	--	12.0	--	--	--	--
Wash, high and low	1.0	--	2.4	2.4	25.0	[a]	25.0	--	--
Wash high	1.0	--	1.2	1.2	--	[a]	50.0	[a]	50.0
Wash low	1.0	--	1.2	1.2	--	[a]	50.0	[a]	50.0
Scale	1.0	--	.8	.8	--	[a]	75.0	[a]	75.0
Shroud, high and low	1.0	--	1.7	1.7	--	[a]	35.0	[a]	35.0
Shroud high	1.0	--	1.2	1.2	--	[a]	50.0	[a]	50.0
Shroud low	1.0	--	1.2	1.2	--	[a]	50.0	[a]	50.0

[a] These jobs involve one man and are generally independent of the number of beds in the plant.

[b] Dashes indicate that the particular work combination concerned was not observed in that size of plant.

[c] For very small crews, the output capacity per bed is basically equal to the total capacity since all the workers will be working on one bed at the same time.

[d] Total capacity equals twice the per bed output rate.

[e] Total capacity equals 2.5 times the per bed output rate.

[f] Total capacity equals 1.5 times the per bed output rate.

[g] Total capacity equals 3.0 times the per bed output rate, since time requirements include time carcass is idle.

Source: The time requirement figures were derived from time studies of actual cattle slaughtering plants in California. The time requirements for jobs which required only one worker and which were independent of the number of beds, e.g., knocking, shackling, etc., were averages of the observations over the entire range of plants studied. Production capacity was derived by dividing 60 minutes by the time required to handle one carcass.

the multiple-bed time requirements, but will be considered in setting up work standards later.

The number of observations in the time study samples of the various operations ranged from four for a combined high and low washing operation to 48 observations for the various crews performing siding and legging work. Although the data are limited with respect to number, the time requirements for the same job performed by the same number of workers were quite similar over different plants. For example, the six-man siding and legging crews in the 2 three-bed plants studies averaged one carcass of output every 2.9 minutes in one plant and 3.0 minutes in the other. The time requirements for specific operations also are comparable to those found in a study of one-bed plants in Texas by Hammons and Miller.[1/]

For all skinning operations, the workers use hand skinning knives as opposed to air-powered knives. Although the latter knives seem to offer less chance of injury because of their construction, in conventional operations there is evidently some resistance to their use by workers who are accustomed to hand knives. In the on-the-rail systems, more use is made of the air-powered knives.

With the exception of the one-bed operations, the siding and legging observations were for plants using a pritch plate instead of a cradle. However, there is indication that the cradle offers the better means of siding and legging.[2/] The cradle eliminates need for the pritch bar, thus allowing both sides of the carcass to be skinned simultaneously. Less stooping is required of the workers since the animal is supported off the floor. Finally, the cradle eliminates the hazard of blood and dirt entering the floor area beneath the pritch plates.

[1/] See Hammons, Donald R., and Jarvis E. Miller, Improving Methods and Facilities for Cattle Slaughtering Plants in the Southwest, Washington D.C., U.S. Department of Agriculture, in cooperation with Texas Agricultural Experiment Station, Marketing Research Report No. 436, Agricultural Marketing Service, 1961.

The apparent similarity in efficiency of operations might be expected *a priori* in view of the data and regulations on plant design and operation issued by the Meat Inspection Division of the U.S. Department of Agriculture. Technological advances are also widely communicated to packers by equipment manufacturing concerns.

[2/] Hammons, op. cit., page 6.

For splitting, combined high and low washing, and the combined high and low shrouding, the worker utilizes a hydraulic lift platform.

The scaling operation is based on use of a dial scale as opposed to a beam scale.

These time requirements are averages for beef cattle with dressed weight of 600 pounds or more. However, there are many factors causing deviations from such averages. During rainy seasons animals are dirtier than usual and may require more handling. Dairy cattle require more time to skin than do fat beef cattle, and some breeds require more washing because of the fine texture of their hair.

The average time requirements observed in actual plants for each operation for a specified crew size are given in Table 3. These operations may be considered as those which are essentially one-man jobs and those which require crew organization. For one-man jobs, such as those listed under "kill, remove head, and wash head," "carcass finishing," and certain other jobs such as splitting and scribing, the average time per head is shown as equal for one-, two-, and three-bed plants. Time requirements for these jobs were found to be approximately the same among such plants, and thus an average figure for all plants is used. This is not the case for the crew organization required for the siding and rumping operations. Here, time requirements relate to the particular scale of plant since at certain levels of output in the multiple-bed plants, a worker may perform the siding operation on an animal in the first bed and then move to the second bed to perform the same operation before returning to the first bed. The time requirements shown in Table 3 for the multiple-bed plants, as noted previously, relate to the time span during which a specific operation is performed on a carcass.

The production capacities for various crew sizes are determined from the time requirements, and also are shown in Table 3 in terms of number of cattle per hour. For the one-bed plant, the production capacity per hour is simply the average time required per head, in minutes, divided into 60, the number of minutes per hour. For the multiple-bed plants, however, the production capacity of the several beds is some multiple of the output of one bed. The operation of a multiple-bed plant operated at capacity rate replicates much of the labor required for one bed. But as discussed above, when operated at less than capacity, workers in some operations shift from one bed to the other to perform the same job. Thus, the total output from the several beds is more than would be obtained by dividing the time required per carcass into 60 to obtain the production capacity. Appropriate adjustments thus are made as will be discussed subsequently.

Synthesized Crews

The capacities in number of head per hour for the various operations served as a basis for synthesizing most of the killing crew requirements for various rates of processing. The number of workers performing head trimming, offal, and tripe work-up were based on labor specifications from the Allbright-Nell Co., a packing plant equipment manufacturing concern. These specifications, based on time studies made by that company, were used because of the lack of standardization of such operations in the plants studies and are based on sale of by-products to a rendering concern.

The various stages of operation in a slaughter plant exhibit different capacities. Capacity output for a given plant, then, is generally that level of production which is a "common denominator" for the range of capacities of the different stages. The "common denominator" for the conventional bed-type plants is limited by the capacity of the rumping and backing operation, a task which is duplicated as new beds are added. After the rumping and backing crew for one bed reaches two workers, little output can be gained by use of additional workers in this operation. The nature of the work and the size of the carcass are such that the work area is too small for more than two men -- one working on each side of the animal.

From the time study observations, the capacity of two men rumping and backing on one bed was calculated as 17.6 head per hour. A level of 17 head hourly was then used as the production capacity of a one-bed plant. Output from a two-bed plant could be expected to be double that of a one-bed plant inasmuch as operations following the convergence of the two beds into one line (splitting, scribing, washing, shrouding, and scaling) become specialized, and these latter workers have capacities exceeding the limit imposed by the rumping and backing operation. The three-bed plant capacity, however, does not jump by an increment of 17 or 18 head per hour, but goes from 35 to 50 head, an increase of 15 head per hour. If the rumping and backing operation were the only limit, one would anticipate production of 52 to 53 head hourly. However, as can be seen from Table 3, many of the operations following the rumping and backing have capacities of 50 head per hour. Thus, if output is pushed to 52 head per hour, the cost of adding the needed workers and equipment, both on the killing floor and in other department, would increase the average cost of slaughtering.[1]

Crews were synthesized for the following short-run outputs in given plants: one-bed plant, 10, 12, 15, and 17 head per hour; two-bed plant, 15 to 35 head per hour; and three-bed plant, 30 to 50 head per hour. The crews represent the minimum number of workers needed for a specific output, i.e., to increase output will require additional workers.

One-bed plants.--The one-bed plant is the basic unit of most conventional bed-type operations. Larger plants generally expand by duplicating beds for the siding, legging, rumping,backing, gutting, and hide dropping operations. Many operations in the small plants are combined in such a manner that they may be handled by one man (see Table 4). Thus, to dress ten head per hour, one man handles the knocking, shackling, sticking, facing, heading, and head washing tasks. One man does both siding and legging, one man performs the rumping, backing, and eviscerating, and another man works

---

[1] Existing plants may have production levels lower than the capacities specified above for a number of reasons. The killing area may be too small for efficient operation in cases where new beds have been added to an existing plant without significantly altering the killing floor area itself. Cooler space may not permit storage of the number of animals which could be handled at capacity operation of the killing floor. Also, a small increment in output may require investment in equipment which cannot be operated to full capacity, or which may have long periods of operation at under-capacity rates because of seasonal effects. For example, in increasing output from 45 to 50 head per hour in a three-bed plant, an additional splitter is required. This extra unit of labor also requires investment in a hydraulic lift platform, a power splitting saw and balancer, and a pneumatic spreader on the rail. These additional items would have over capacity, and for that reason the entrepreneur might desire to operate with only one splitter at 45 head per hour.

TABLE 4

Synthesized Crew Sizes for One-Bed Plants with Varying Rates of Output

Operation	Output per hour, in number of head							
	10		12		15		17	
	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.
Kill, remove head, and wash head:								
Knock, shackle, stick face, head, wash head	1.0	14.6	1.0	14.6	1.0	14.6	--	--
Knock, shackle, stick	--	--	--	--	--	--	1.0	40.0
Face, remove head, wash head	--	--	--	--	--	--	1.0	28.6
Remove hide, eviscerate, split, and scribe:								
Side, leg	1.5	13.6	2.0	14.3	2.5	21.4	2.5	21.4
Rump, back, gut	1.5	10.2	2.0	12.8	a/	--	--	--
Rump, back	--	--	--	--	2.0	17.6	2.0	17.6
Gut, truck, hang offal	--	--	--	--	1.0	23.1	1.0	23.1
Hide, drop, split, scribe	1.0	13.3	1.0	13.3	--	--	--	--
Hide drop	--	--	--	--	.5	20.0	.5	20.0
Split	--	--	--	--	.5	23.1	.5	23.1
Scribe	--	--	--	--	.5	25.0	.5	25.1
Carcass finishing:								
Wash, scale, shroud	1.0	12.0	1.0	12.0	--	--	--	--
Wash, high and low	--	--	--	--	1.0	25.0	1.0	25.0
Scale and shroud	--	--	--	--	1.0	20.7	1.0	20.7
Other:								
Head work-up	1.0	b/	1.0	b/	1.0	b/	1.0	b/
Truck guts	.5	b/	.5	b/	c/	--	c/	--
Tripe work-up	.5	b/	.5	b/	1.0	b/	1.0	b/
Offal work-up	c/	--	c/	--	c/	b/	c/	b/
TOTAL	8.0		9.0		12.0		13.0	

a/ Dashes indicate the position is not utilized as specified for the particular output level in question.

b/ Because of the insufficient time study data, crew requirements in these cases were synthesized from (observed) crew organization reported in a mail questionnaire of labor requirements for a sample of 17 California slaughter plants.

c/ Head work-up man also handles the offal work-up, except for output levels of 15 head per hour. For this production rate, the worker performing the evisceration also does the offal work-up and the guts trucking.

Source: Crew requirements were synthesized from production capacity data given in Table 3.

half time in each of these two operations. Dropping the hide, splitting the carcass, and scribing are similarly delegated to a single worker, as are washing, scaling, and shrouding. In addition, another worker handles the offal, trims the cheek meat, tongues and splits the head. Finally, one worker pushes the paunch truck and separates the tripe. Hence, for a small output of ten head per hour, eight men perform some 23 different functions.

Nine workers are then needed to slaughter 12 head, 12 workers to kill 15 head and finally 13 men to slaughter 17 head per hour.

With such incremental additions to the labor input (because of indivisibilities) the production function becomes a step function rather than a smooth, continuous function. Table 4 shows the input-output relationship for labor in a one-bed slaughter plant. (Tables for similar developments for other plants will be found in the appendix.)

Two-bed plants.--Many operations for a one-bed plant are duplicated in the multi-bed plants. However, generally the knocking, sticking, splitting, washing, scaling, and shrouding are performed on only one line.

Crew specifications for different outputs of the two-bed plants are given in Appendix Table A-1.

For outputs of less than 17 head per hour, the two-bed plant essentially performs as a one-bed establishment, operating just one line to full capacity. At other low levels of output in multiple-bed plants, crews may work on both lines and thus obtain greater output with the same number of men than a one-bed plant. For instance, 12 men are required to dress 20 head hourly in a two-bed plant -- the same number as required for 15 head in the one-bed plant. In the former case, however, the floorsmen can complete work on one carcass, leave it in position on the pritch plate or cradle, and begin work on a new carcass on the second bed. Similarly, while the backer is finishing his work on one bed, the rumper (working half time in this capacity) can be hoisting another animal into place and starting work on the other bed.

At low production levels (less than 25 head per hour) all of the crew for any given operation will be working on the same bed at the same time.

Capacity is thus reflected in the time required to handle one carcass. For larger output rates, this does not hold true. The rumping and backing crew may be working over both beds simultaneously. In this case, the output capacity is not double the rate given in the table but is approximately 1.5 times that rate.[1]

In the siding and legging operations for the higher rates of kill, the legger may start work on a new carcass, lowering it to the cradle and cutting the legs off while the other floorsmen finish the previous animal. Thus the actions on the two beds are not independent of each other. Even at the top rates of output for the two-bed plant, workers do not stay at one bed, but work from one bed to the other. As in the case of the rumping and backing operation, the capacity of a particular crew in the flooring operation was about 1.5 times the rate of speed at which they handle one complete animal[2] (In the case of a five-man flooring crew, output was twice the rate for one animal since both beds are operating at capacity.)

Three-bed plants.--Three-bed firms producing at low output rates also can be considered as operating only on one or two beds with the unneeded facilities not used. Some of the more specialized operations found in larger production rates, however, may prohibit large plants from operating with as small a crew as the one- or two-bed plants at comparable outputs. For instance, to reduce output in a plant utilizing both a high and a low washer on stationary platforms may mean that both washers will have to be retained since the equipment is geared for both washers.

Data for the lower output ranges with small flooring and rumping and backing crews, however, were not available for the three-bed plants. The capacity rates in these cases were either derived from those for a two-bed plant or assumed to be the same as the two-bed plant (see Appendix Table A-2). Thus, for the siding and legging operation, the output capacity per hour for crews through the four-man size was 1.5 times the rate exhibited for one animal. For the five-man crew, total output should equal at least the peak output of such a crew for the two-bed plant, or 48 head per hour. Finally, an output-capacity ratio similar to those described for the two-bed plant was derived for the six-man flooring crew under which two beds are producing at full capacity, while the third bed is operating at partial production capacity. The ratio was 2.5.

---

[1] This ratio was estimated by dividing the actual production per hour in three of the two-bed plants observed by the rate at which a rumping and backing crew was operating on one bed. Where there was interchange of workers among beds. The ratio of actual output to capacity per bed for a particular size of crew closely approximated the 1.5 ratio used. Where both beds were utilized to capacity in the rumping and backing operation with two men per bed, output, of course, was then simply double the one-bed rate for a crew of two men.

[2] The ratio for the siding and legging operation was estimated on the same basis as rumping and backing, only with observations from two plants. Again with a crew of five men in the flooring operation, both beds were specified to operate at the full capacity of having 2.5 men per bed.

Similar specifications are made for the rumping and backing. For 25 and 30 head hourly, the crews produce about 1.5 times the rate established for one animal since with a crew of one rumper and two backers, operations will generally occur simultaneously on two of the three beds. For 35 head per hour, an additional man should allow full operation of two beds all the time. For 40 and 45 head, all three beds will be operating simultaneously, although the two rumpers will alternate operations among the three beds, and finally for 50 head hourly, all beds will be operating at full capacity.[1]

Labor Requirements for Killing and Dressing -- On-The-Rail Plants

Because of limited information on California plants using the on-the-rail system, labor requirements were derived from specifications of manufacturing concerns. Available data related to operation of plants at capacity levels; therefore, no attempt was made to estimate short-run cost curves for these plants. Some changes were made from the manufacturers' crew specifications since, for example, most of the carcass splitting in California is performed by one man on a hydraulic lift platform, whereas in other areas of the country, the carcass is split section-by-section by specialized workers. The method used, it appears, is dependent on the preferences of the customers since the appearance of the cut areas differs between the two methods. For purposes of this study, one man was designated to perform the entire splitting operation up to his output capacity -- at which point a man would be added who also does the complete operation.

---

[1] Except for capacity output of the four-man rumping and backing crew, other specifications were derived from the data obtained in two-bed operations.

Because of the incomplete and non-uniform nature of labor data for the Can-Pak system, the information on such needs from the Allbright-Nell Co. was used as a basis for determining the labor costs for on-the-rail dressing. These crew figures are general plant requirements and thus may not apply to specific situations.

As mentioned above, the major differences between the Can-Pak and the Bovi-Mation systems is in the use of the hydraulic hide puller. The hide puller for large outputs reduces the number of laborers engaged in the siding operation; one worker is required to operate the machine. There are no clear-cut lines defining the most profitable point to use the hide pulling machine. Maintenance costs for the machine in the past have been high. Neglecting the maintenance costs, however, use of a hydraulic hide pulling machine (cost = $15,000) becomes profitable when the savings in labor costs equal or surpass the allocation for depreciation, interest, insurance, and tax costs of the machine. Thus, for kill rates of 40 head per hour or less, the use of a hide pulling machine may not result in lowering the labor requirements inasmuch as workers performing the siding also do other tasks. However, for outputs of 60 head per hour or more in which two or more workers specialize in the siding operation, use of the hide pulling device decreases expense by eliminating one or more labor positions which cost $7,591 annually each, while adding a lesser amount, $2,719, to costs of depreciation, insurance, taxes, and interest charges.

The derived labor requirements for on-the-rail systems covering outputs of 20, 40, 60, 75, and 120 head per hour are found in Appendix Tables A-3 and A-4.

Labor Requirements for Cooler, Dock, Maintenance, Yard, and Clean-Up Work

Observations of actual plants afforded no basis for specifying the number of men working in coolers, on the dock, on maintenance or on clean-up. Labor requirements in these departments varied as plants did or did not render their own by-products, or did or did not make sausage.

In order to derive standards for cooler and dock personnel (see Table 5), the time requirements estimated by Hammons and Miller for these operations for cattle of 600 pounds and over were used.[1] From their time findings, it was calculated that a four-man crew in the cooler could assemble orders at the rate of 54.5 carcasses (sawed in halves) per hour or 408.8 carcasses per day. One man in the cooler crew could move carcasses from the chill box to the holding cooler at the rate of 100 head per hour or 750 head per day, while another worker could remove the shrouds (using a hand truck to gather them from the floor) at the rate of 80 head per hour or 600 head per day.[2]

In the smaller plants, cooler crews may also load the outgoing trucks. Under the method of loading outlined by Hammons and Miller, the carcasses are transported on the rail from the cooler to the dock, weighed, and placed in the truck which also utilizes overhead rails.[3] Four workers performing this type of loading can load approximately 120 head of cattle per hour.[4]

Each plant was assumed to load out approximately one day's kill every day. Therefore, for small plants killing 10 to 17 head per hour, the cooler workers can also perform the dock or loading jobs. The dock workers also often serve as equipment cleaners, washing and oiling the beef trolleys and returning them to the kill floor. Hence, in estimating the number of men required, extra time was allowed to enable the workers to perform the additional tasks.

Under the method of loading the carcasses on the trucks outlined by Hammons and Miller, a four-man crew would suffice for all ranges of output considered here.

---

[1] Hammons and Miller, op. cit., pp. 48-49.

[2] Assumes 30 minutes of an eight-hour shift are allocated to rest periods. Daily output, then, equals the hourly rate times 7.5 hours.

[3] Hammons and Miller, op. cit., p. 25.

[4] Much of the beef in California currently is loaded by quarters, with the rear quarters being suspended by hooks from beams in the top of the truck. The fore quarters are stacked on the floor of the truck between layers of paper. By this method, however, Hammons' and Miller's time estimates yield a loading capacity of 54.5 head per hour with five men working on the dock. Because of its greater speed, lower labor requirements and ease of handling, the former method was used in calculating needed dock workers.

TABLE 5

Synthesized Crews for Cooler, Dock, Maintenance, Yard, and Clean-Up Work

Operation	Number of employees required for plants with hourly kills of											
	10	17	20	25	30	35	40	45	50	60	75	120
Cooler:	3	4	4	4	4	4	5	6	6	8	8	12
Dock:												
Foreman	1[a]	1[a]	1	1	1	1	1	1	1	1	1	1
Order clerk	--[b]	--	--	1	1	2	2	2	2	2	2	2
Checkers	--	--	--	--	1	1	1	1	1	1	1	2
TOTAL	--[a]	--[a]	1	2	3	4	4	4	4	4	4	5
Maintenance:												
Foreman	--	--	--	--	--	--	1	1	1	1	1	1
Gang leader	--	--	1	1	1	1	--	--	--	--	--	--
Workers	1	1	1	1	2	2	4	4	4	5	6	9
TOTAL	1	1	2	2	3	3	5	5	5	6	7	10
Yardmen:	1	1	1	1	1	1	2	2	2	2	2	3
Clean-up:												
One-bed	1	1	--	--	--	--	--	--	--	--		
Two-bed	--	--	2	2	2	2	--	--	--	--		
Three-bed	--	--	--	--	3	3	3	3	--	--		
On-the-rail	1	1	1	2	2	2	2	3	3	3	4	5

a/ Foreman in these instances is included in the cooler crew.

b/ Dashes indicate this position is not utilized as specified for the particular output rate in question.

Source: Cooler, dock, and clean-up personnel specifications are based on time requirements given by Hammons and Miller, op. cit., pp. 48-49. Maintenance and yard crews are based on crew organizations founded in a sample of 15 California slaughter plants.

The maintenance crew and yardmen requirements were based on observations of actual plants in California. From a sample of 14 plants there appeared to be a definite division in the case of yardmen with plants killing less than 40 head per hour having one yardman and those killing more needing two. Similarly, the maintenance crews seemed to have uniform groupings for the various output ranges. Two plants killing less than 20 head per hour had 1 maintenance man, 4 of the 5 plants killing 20 to 30 head per hour utilized 2 men, while 2 of the 4 plants slaughtering 30 to 40 head hourly had crews of 3 men (the other 2 plants had 4 and 5 men each). Finally, 2 plants killing 40 to 50 head per hour had maintenance crews of 5 and 6 men respectively, and 2 plants killing more than 50 head per hour reported crews of 8 and 16 men, although the latter plant has extensive sausage-making and boning operations. Fewer men would be required in the latter plant, if only slaughtering were performed. In general, modal values of these groupings were used as the basis for selecting the maintenance crews for the synthesized plants.

The number of clean-up men was based on the square footage of floor space of the various departments in the plants. Cleaning time requirements for specific departments again were based on the study by Hammons and Miller.1/

The time requirements for cleaning the various types of rooms in the specified one-, two-, and three-bed plants are listed in Table 6. For the one-bed plant, the time required to clean the entire plant is such that one man could perform the operation with enough extra time to allow him to help clean the beef trolleys and arrange the tripe barrels and hides on the basement loading dock during the latter part of the kill crew's work day (or during the initial part of the clean-up crew's work period). The actual clean-up work begins after the killing operation has ceased for the day.

In the two-bed plant, two clean-up workers would be required since the time requirement is more than can be handled by one person. The two workers would allocate their nonclean-up work time to similar operations as with their one-bed counterpart, a procedure common to the California plants studied.

1/ Hammons and Miller, op. cit., page 9.

TABLE 6

Cleaning Time Requirements for Synthesized Plants

Building area	Cleaning rate per hour (sq. ft.)	Number of hours required to clean							
		Conventional plants with			On-the-rail plants killing per hour				
		one-bed	two-bed	three-bed	20-head	40-head	60-head	75-head	120-head
Kill floor	558.3	3.30	4.84	6.64	2.20	5.76	9.21	9.37	14.48
Cooler	2,553.2	1.24	2.22	3.08	1.43	2.65	3.70	4.59	7.21
Office	2,553.2	.40	.74	.99	.45	.83	1.16	1.32	1.86
Employee dressing	2,553.2	a/	.26	.38	.17	.33	.45	.52	.79
Equipment clean-up	2,275.0	.10	.10	.10	.10	.10	.10	.10	.10
Refrigeration	2,553.2	.20	.12	.15	.09	.09	.31	.31	.31
Boiler	2,553.2	b/	.09	.12	.08	.14	.17	.19	.21
Dry storage	2,553.2	.22	.08	.11	.06	.09	.13	.17	.27
Basement	2,490.0	.21	.43	.62	.25	.50	.74	.93	1.49
Dock	2,490.0	.09	.29	.34	.17	.40	.54	.67	.69
TOTAL		5.76	9.17	12.53	5.00	10.89	16.51	18.17	27.41

a/ Included in dry storage.

b/ Included in refrigeration.

Source: Column 1 - Based on Hammons and Miller, op. cit., p. 29.
Columns 2-9 - Derived by dividing floor areas of synthesized plants (Section V) by column 1.

For the three-bed plant, two workers could perform the clean-up operation, but would have little time left to clean beef trolleys or work on the tripe and hide load out dock. Hence, three clean-up workers would be used in three-bed plants.

Office, Buying, and Selling Personnel

The number of office and administrative personnel in the plants observed increased irregularly from 1 office worker for the 2 small plants killing 10 and 20 head per hour to 8 and 9 workers respectively, in the plants slaughtering 55 and 60 head per hour. In the smaller plants, however, the owner-managers also perform some of the bookkeeping tasks, while in the larger plants, diversified operations may require more office personnel than would be needed with just a slaughtering operation. For these reasons, the figures obtained from the plant studies were used more as a guide, and the synthesized office force was developed on the basis that as the daily kill increased, the various accounting and bookkeeping operations would require more specialized attention.

The synthesized office forces are given in Table 7 for various sizes of plants. In actual situations these jobs may, of course, be reorganized with different combinations of responsibilities.

A similar procedure was followed to specify the number of buyers and salesmen needed. The number of buyers had the following pattern in relation to output which was used to synthesize requirements for these positions: From a sample of 15 slaughter plants, all plants killing 20 head per hour or less employed 1 buyer, while those slaughtering between 20 head and 40 head used an average of 2 buyers; plants slaughtering between 40 and 60 head per hour reported 5 buyers. The selling side was variable. The number of salesmen depends on how many products the firm produces and to what extent the products are contracted for by large purchasing retail or wholesale outlets. The plants killing from 25 head per hour to 45 head exhibited a selling force with a modal value of 3 persons. This value, then, was used as a basis for establishing selling forces for the other sizes of plants. Plants killing less than 25 head per hour were assigned a sales force of 2 men, while those killing over 45 were given an additional salesman for every extra 10 head slaughtered per hour.

TABLE 7

Synthesized Salaried Personnel Requirements for Varying Rates of Output

Operation	Number of salaried employees required for plants with hourly kills of							
	17	20	35	40	50	60	75	120
Office:								
Switch board	a/	--	--	1	1	1	1	1
Payroll and accounts payable	--	1	1	1	1	1	1	2
General	--	--	--	1	1	1	1	3
Credit manager and livestock payable	--	--	--	1	1	1	1	2
General ledger and office manager	--	--	--	1	1	1	1	2
Phone, billing, posting, invoicing	1	1	2	--	1	2	2	3
General ledger credit and accounts payable	1	1	1	--	--	--	--	--
TOTAL OFFICE	2	3	4	5	6	7	7	13
Buyers:	1	1	2	2	3	5	5	7
Sellers:	2	2	3	3	4	5	6	9
Management:								
General manager	1	1	1	1	1	1	1	1
Senior buyer	--	--	1	1	1	1	1	1
Sales manager	--	--	1	1	1	1	1	1
Plant superientendent	--	--	--	1	1	1	1	1
Assistant plant superintendent	--	--	--	--	--	1	1	1

a/ Dashes indicate the position is not utilized as specified.

Source: Employee specifications are based on the sample of seven plants which were studied in detail.

Management Personnel

Many independent plants -- and particularly the small plants -- are managed by the owners. If the plant is owned by two or three individuals, each one will assume the management responsibilities for a particular area of operation. Thus, the distinction between buyers, salesmen, and management may not be as clear-cut as the divisions in Table 7 might indicate.

Despite the complex situation of combined ownership and management, a hierarchy of command appeared to exist in the plants studied, i.e., one person supervises buying, another directs selling, and finally a third serves as general manager over plant and co-ordinates all the firm's activities. These operations might be classed respectively as (1) senior buyer, (2) sales manager, and (3) general manager. The specifications for these management positions were based on interviews with slaughter plant officials with regard to the question of what management personnel would be needed if the owners did not perform such tasks.

In the 8 plants surveyed, after output reached 40 head per hour, a plant superintendent was added to manage the plant operations and serve as liaison between the production area and the front office. At 60 head per hour, an assistant plant superintendent was added.

Labor Costs -- Union Workers

The union and non-union divisions of labor are for the most part synonymous with variable and fixed labor. The amount of union labor on the kill floor, in the coolers, on the dock, and for other work directly associated with the processing is dependent upon the rate of slaughtering.1/ On the other hand, the amount of office personnel and administrative workers for a given plant generally remains the same in the short-run despite fluctuations in production rates.

Hourly wage rates for union workers vary by location over the state. In order to standardize the costs of slaughtering cattle, the union wage

---

1/ Institutional factors such as union contracts may limit the degree of variability of such factors. Thus workers may be guaranteed a 40-hour week which prevents day-by-day variation of the work force.

scale for the conventional kill system was derived from the labor contract between the Butchers' Union, Local No. 563 (affiliated with the Amalgamated Meat Cutters and Butcher Workmen of North America) A.F.L. - C.I.O. and the independent meat packing companies of Los Angeles County.[1] The rates used then were those in effect from October 1, 1960, through September 30, 1961. The wage rates for the various jobs are scaled by brackets (each bracket represents $.04 per hour) from the lowest level or zero bracket for common labor.

The contract for Local No. 563, however, does not specify wage rates for on-the-rail systems. For this reason, the bracket classifications for on-the-rail dressing were taken from a contract between the United Packinghouse Workers of America, A.F.L. - C.I.O., and Swift & Co. covering the period October 23, 1959, to September 1, 1961.[2] The bracket classifications for identical operations for the two contracts were nearly the same. One adjustment was made in the Swift contract for the on-the-rail system; the hide dropper classification was increased one bracket to conform with the wage scale for that job for Local No. 563. The wage rates under the contract of Local No. 563 were then applied to the on-the-rail brackets.

The total annual wages for the various operations, listed in Appendix Table A-5, are combinations of basic wage rates, fringe benefits, vacation pay, sick leave pay, and holiday costs, based on 260 working days or 2,080 hours a year including holidays. Fringe benefits include $0.40 a week in lieu of necessary tools,[3] $1.00 per week in lieu of employee's taking time for changing clothes before and after work,[4] $14.50 per month per employee for health and welfare benefits,[5] and $0.10 per hour per employee for the pension fund.[1] For the kill floor personnel, the fringe benefits total $454.80 a year; while for the non-kill floor union workers, the total is $434.00 a year (tool allowance omitted).

---

[1] Working Agreement and Wage Scale, October 1, 1959, by and between the Butchers' Union, Local No. 563, A.F.L. - C.I.O., and Independent Meat Packers of Los Angeles County, California.

[2] Swift & Company Master Agreement with United Packinghouse Workers of America (A.F.L. - C.I.O.) Covering Period October 23, 1959, to September 1, 1961.

[3] Working Agreement and Wage Scale, op. cit., page 4.

[4] Ibid., page 4.

[5] Ibid., page 18. Does not include social security.

Each employee who has been with the firm one year qualified for one week of vacation with pay.[2] Although employees with more years seniority may receive more than one week, it was assumed that each worker received one week of vacation. To calculate costs of both vacation and sick leave -- also one week per year -- the worker's regular wage rate plus $0.10 was multiplied times the normal 40-hour work week.[3] The extra $0.10 per hour is the amount the firm must pay the extra man hired temporarily to replace the one on vacation above the normal pay rate for any given job.[4]

The union contract calls for eight paid holidays. This is non-working time of 64 hours for which the worker must be paid his normal wage rate.[5]

Two additional contract items directly affect the labor costs both in the conventional and on-the-rail systems. First, under the contract agreement for Local No. 563, the workers are guaranteed 40 hours of work Monday through Friday, with eight hours being worked on each day.[6] In addition, workers are allowed two rest periods "without deduction of pay, at regular times in each shift to be mutually agreed upon by the employer and the union, A.M. fifteen (15) minutes, P.M. ten (10) minutes."[7] Therefore, the worker will be paid for eight hours a day, but the actual working time will be seven (7) hours 35 minutes after deduction of the rest periods. In this analysis, rest periods were specified to consume a half-hour daily. Thus, the total daily output will be 7.5 times the hourly kill rate, while the total daily cost will be eight hours times the hourly wage rate.

Second, if a worker performs two operations, as is often the case, he will be paid the higher rate of the two tasks. Thus, if a man knocks, shackles, and sticks the animal, he will be paid $3.29 an hour which is the sticker's rate since that is the highest of the three jobs.

---

[1] Working Agreement and Wage Scale, op. cit., page 19.

[2] Ibid., page 12.

[3] Ibid., page 5.

[4] Ibid., page 16.

[5] Ibid., page 14.

[6] Ibid., page 15.

[7] Ibid., page 3.

Killing and Dressing Crew

Conventional bed-type plant.--The crew specifications for the one-bed plant with the associated wage rates are listed in Table 8. Similar wage costs for the two- and three-bed plants are given in Appendix Tables A-6 and A-7. In all plants one worker on the kill floor is designated as foreman and is paid nine brackets (36 cents per hour) above the highest classification on the floor. In order to be consistent, a backer was selected as foreman and was paid at the higher rate.

In the two- and three-bed plants, a change in technology is involved at certain rate changes. For the two-bed plant, the washing operation for 20 and 25 cattle per hour is based on one worker using a hydraulic lift platform. However, a two-bed plant built for operations at higher rates would utilize two washers, each standing on a stationary platform at different levels. In the latter case, if output is reduced, the plant would still use a high and a low washer, and its short-run costs for labor would be higher than those of the plant using a hydraulic lift. The same is true of the shrouding operation. In Appendix Table A-6 the figures in parentheses represent the short-run costs for such a firm with stationary platforms. The same is true for the figures in parentheses in Appendix Table A-7 for the three-bed plants.

On-the-rail system.--The wage rates in Appendix Table A-5 were similarly applied to the labor standards for on-the-rail operations. Many of the operations in the more automated plants (for example the evisceration, offal work-up, head washing, etc.) are paid the same rates as under the conventional bed plants. Thus, if the labor classification of a particular worker is not listed under the on-the-rail section of Appendix Table A-5, the appropriate wage bracket can be found under the wage section pertaining to bed-type plants. The labor costs for the derived labor crews are given in Appendix Tables A-8 and A-9.

TABLE 8

Kill Crew Annual Labor Cost in One-Bed Plant for Various Rates of Output

Operation	Output per hour, in number of head							
	10		12		15		17	
	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker
		dollars		dollars		dollars		dollars
Kill, remove head and wash head:								
Knock, shackle, stick face, head, wash head	1.0	6,640	1.0	6,640	1.0	6,640	--[a]	
Knock, shackle, stick	--		--		--		1.0	6,640
Face, head, wash head	--		--		--		1.0	6,640
Remove hide, eviscerate, split, and scribe:								
Side, leg	1.5	7,591	2.0	7,591[b]	2.5	7,591	2.5	7,591
Rump, back, gut	1.5	8,368[c]	2.0	8,368[c]	--		--	
Rump, back	--		--		2.0	8,368[c]	2.0	8,368[c]
Truck guts, gut, hang offal	--		--		1.0	6,381	1.0	6,381
Drop hide, split, scribe	1.0	7,591	1.0	7,591	--		--	
Drop hide	--		--		.5	6,640	.5	6,640
Split	--		--		.5	7,591	.5	7,591
Scribe	--		--		.5	[d]	.5	[d]
Carcass finishing:								
Wash, scale, shroud	1.0	6,208	1.0	6,208	--		--	
Wash, high and low	--		--		1.0	6,036	1.0	6,036
Scale and shroud	--		--		1.0	6,208	1.0	6,208
Other:								
Head work-up	1.0	6,295	1.0	6,295	1.0	6,295	1.0	6,295
Truck guts	.5	[d]	.5	[d]	--		--	
Tripe work-up	.5	6,295	.5	6,295	1.0	6,295	1.0	6,295
Offal work-up	--		--		--		--	
TOTAL	8.0	56,060	9.0	62,355	12.0	82,708	13.0	89,348

[a] Dashes indicate the position is not utilized as specified for the particular output level in question.

[b] One worker is paid at legger's rate at $6,295.

[c] One worker is paid at rumper's rate at $7,072.

[d] Laborers dividing their time between two or more different jobs are paid the full amount of the higher-paying classification.

Source: Crew requirements are taken from Table 4, and wage rates are taken from Table A-5.

Maintenance, Yardmen, Coolermen, and Dockmen

As mentioned earlier, the number of workers employed in maintenance, cooler, dock, and yard operations varies with the number of head killed, and is not greatly influenced by the differences in the scale of the killing operation other than by changes in the production rate of carcasses. Thus, the cooler and dock crew needed for a kill of 262 head a day (35 an hour) will be the same whether the animals are processed in a two-bed or a three-bed plant.

As in the case of the killing crews, the wage rates listed in Appendix Table A-5 were applied to the synthesized crews derived earlier. (see Appendix Table A-10).

A dock foreman was used for each dock and cooler crew. For the smaller maintenance crews, a gang leader was utilized instead of a foreman. The gang leader directs the maintenance work, but does not have the policy or administrative authority of the foreman. Following a policy outlined by butcher union officials, a foreman was assigned to crews of four men or larger. Since most clean-up work is done after the regular killing operation has ceased, the clean-up crew was designated to start work at 1:30 p.m. Under a work day schedule for the kill crew of 7:00 a.m. to 3:30 p.m., a 1:30 p.m. to 10:00 p.m. schedule for the clean-up crew would allow them to spend the first two hours cleaning trolleys and getting the day's by-products arranged for pickup on the tripe and hide load-out dock. The union contract calls for a $0.10 per hour premium for work done between 6:00 p.m. and 6:00 a.m. Hence, the clean-up workers would receive an extra $0.10 per hour for the 6:00 p.m. to 10:00 p.m. work (see Appendix Table A-11).

Labor Costs -- Non-Union Personnel

Office, Buying, and Selling

The salary rates paid office workers were selected from pay scales reported by slaughtering plants in the Los Angeles area. Salaries for comparable office jobs in the Los Angeles plants studied were generally the same without regard to size of plant; therefore no adjustment was made in salary rates by the scale of the plant. The salaries for the various office personnel listed previously are given in Appendix Table A-12.

A similar procedure was followed for the buyers' and salesmen's salaries. A salary scale of $200 a week was used to determine these costs. Actually the salaries of the buyers and salesmen will vary within a particular plant depending on experience and ability. The $200 a week figure represents more of an average salary than an actual figure applying to each buyer or salesman.

Management

If the combined ownership-management makes the task of specifying management personnel complex, then the complexity is compounded in attempting to allocate salaries. Under actual conditions, much of the payment allotted to management represents profits and salaries combined. Most owners are also reluctant to discuss these aspects of costs.

Another problem lies in management cost differences with scale variation. The salary rates applied here were based on a conversation with a packing industry analyst about salaries of executives in similar types of work and in some non-independent or chain meat packing plants. The general manager in a large slaughter house killing 50 head or more per hour was specified to receive an annual salary of $22,500. This figure, then, was scaled downward to $15,000 for general managers of plants killing 10 to 17 head per hour.

Salaries for the sales manager and senior buyer ranged from $12,000 to $15,000 depending on the scale of the plant, with the plant superintendent earning between $10,400 and $13,000 and his assistant getting $10,400 (see Appendix Table A-12).

Total Labor Costs

In combining the various labor cost components into a total figure, the office, buying, selling, and management personnel, were considered as fixed costs. The fixed cost figure used was that level of cost associated with the maximum output possible from the particular size of plant, i.e., 17 head per hour for a one-bed plant, 35 head per hour for the two-bed plant, 20 head per hour for the smallest on-the-rail plant.

Conventional Plants

Total labor costs are given in Tables 9 and 10 and shown in Figure 4 for the conventional plants. Minimum average cost for the one-bed plant was $6.13 a head at a rate of 17 head per hour. For the two-bed plant, it was $5.80 for 35 head per hour with the shrouding done by one worker on a hydraulic lift platform. The minimum average cost in the three-bed plant was $5.88 for 50 head per hour using stationary platforms for both washing and shrouding.

The least cost per head in the two-bed plant is $0.08 less than the similar cost for the three-bed establishment. This apparent diseconomy results from an increased fixed cost per head from $1.88 for the two-bed plant to $1.90 for the three-bed plant and from higher per head costs of the killing crew, maintenance, yard, and clean-up men. These latter costs are $0.16 a head higher for the three-bed plant than for the two-bed plant, a diseconomy which is offset slightly by the $0.10 a head lower cost in the three-bed plant for the cooler workers.

On-The-Rail Plants

These plants exhibit economies of labor costs over all sizes of plants. Much of the decrease in average labor cost comes from the savings in kill crew costs. The cost per head for the kill crew of a plant killing 20 head per hour is $3.03 compared with $2.38 per head for a plant killing

TABLE 9

Total Annual Union Labor Costs for Synthesized Plants

Plants	Kill per hour	Kill per year	Annual kill crew costs	Annual maintenance crew costs	Annual cooler, dock crew costs	Annual yard crew costs	Annual clean-up crew costs	Total annual union costs
	head		dollars					
One-bed plants:								
	10	18,900	56,060	7,311	19,686	5,842	5,777	94,676
	12	22,680	62,355	7,311	26,219	5,842	5,777	107,504
	15	28,224	82,708	7,311	26,219	5,842	5,777	127,857
	17	32,004	89,348	7,311	26,219	5,842	5,777	134,497
Two-bed plants:								
Hydraulic lift wash	20	37,800	82,708	14,881	32,493	5,842	11,554	147,478
Stationary platforms for wash	20	37,800	88,744	14,881	32,493	5,842	11,554	153,514
Hydraulic lift wash	25	47,124	114,787	14,881	38,681	5,842	11,554	185,745
Stationary platforms for wash	25	47,124	120,823	14,881	38,681	5,842	11,554	191,781
Stationary platforms for wash	30	56,700	153,681	22,192	44,955	5,842	11,554	238,224
Stationary platforms for wash	35	66,024	167,826	22,192	51,143	5,842	11,554	258,557
Three-bed plants:								
Hydraulic lift, shroud only	30	56,700	153,681	22,192	44,955	5,842	17,331	244,001
Stationary platforms for wash and shroud	30	56,700	159,889	22,192	44,955	5,842	17,331	250,209
Stationary platforms	35	66,024	180,847	22,192	51,143	5,842	17,331	277,355
Stationary platforms	40	75,600	205,766	37,332	57,417	11,684	17,331	329,530
Stationary platforms	45	84,924	219,220	37,332	63,691	11,684	17,331	349,258
Stationary platforms	50	94,500	246,473	37,332	63,691	11,684	17,331	376,511
On-the-rail plants[a/]:								
A	20	37,800	114,442	14,881	32,493	5,842	57,777	173,435
B	40	75,600	210,766	37,332	57,417	11,684	11,554	328,753
C	60	113,400	287,081	44,643	76,239	11,684	17,331	436,978
D	75	141,624	343,044	51,954	76,239	11,684	23,108	506,029
E	120	226,800	538,974	73,887	107,609	17,526	28,885	766,881

[a/] Synthesized on-the-rail plants will be referred to as A, B, C, D, E, following this table. The kill rate will remain the same.

Source: Column 2 is derived by multiplying the hourly kill by 7.5 hours and then by 252 days. Columns 3 through 7 are taken from Table 8 and Appendix Tables A-6 through A-12. Column 8 is the sum of columns 2 through 7.

TABLE 10

Total Salaried and Combined Labor Costs for Synthesized Plants

Plant	Kill per hour	Annual office labor cost	Annual buying, selling cost	Annual management cost	Total fixed salary cost	Fixed salary cost per head	Total labor cost	Labor cost per head
	head				dollars			
One-bed plants:								
	10	15,600	31,200	15,000	61,800	3.27	156,476	8.28
	12	a/	a/	a/	a/	2.72	169,304	7.46
	15					2.19	189,657	6.72
	17					1.93	196,297	6.13
Two-bed plants:								
Hydraulic lift wash	20	28,340	52,000	44,000	124,340	3.29	271,818	7.19
Stationary platforms for wash	20	a/	a/	a/	a/	3.29	277,854	7.35
Hydraulic lift-wash	25					2.64	310,085	6.58
Stationary platforms for wash	25					2.64	316,121	6.71
Stationary platforms for wash	30					2.19	362,564	6.39
Stationary platforms for wash	35					1.88	382,897	5.80
Three-bed plants:								
Hydraulic lift, shroud only	30	43,940	72,800	62,900	179,640	3.17	423,641	7.47
Stationary platforms for wash and shroud	30	a/	a/	a/	a/	3.17	429,849	7.58
Stationary platforms	35					2.72	456,995	6.92
Stationary platforms	40					2.38	509,170	6.74
Stationary platforms	45					2.12	528,898	6.22
Stationary platforms	50					1.90	556,151	5.88
On-the-rail plants:								
A	20	23,140	31,200	17,500	71,840	1.90	245,275	6.49
B	40	38,740	52,000	54,400	145,140	1.91	473,893	6.27
C	60	49,140	104,000	75,900	229,040	2.02	666,018	5.87
D	75	49,140	114,400	75,900	239,440	1.69	745,469	5.26
E	120	94,380	166,400	86,000	346,780	1.53	1,113,661	4.91

a/ Unless otherwise indicated, the costs in this column are the same as above.

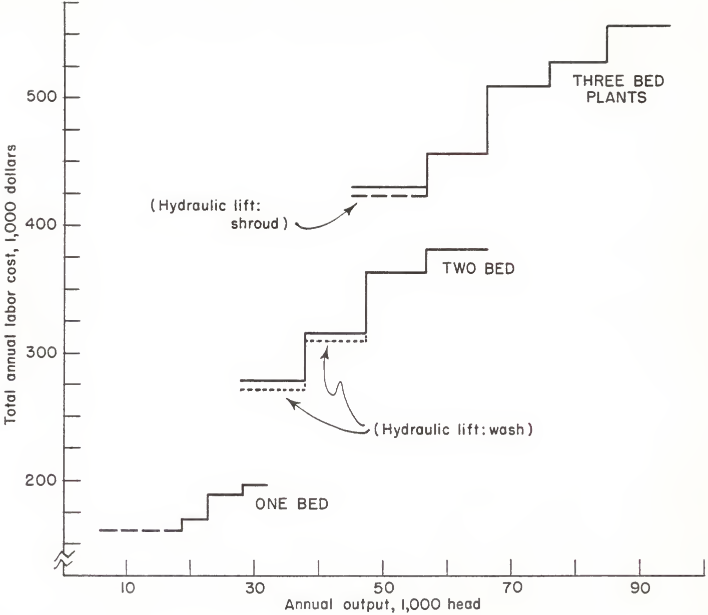


Figure 4. Total Annual Costs of Labor for Synthesized Conventional Plants

120 head per hour. Similar economies are found in the cooler and dock costs and the maintenance, clean-up, and yard labor costs.

From an over-all viewpoint, the smallest on-the-rail plant had an average labor cost per head of $6.49, while the largest plant registered an average labor cost or $4.91, a decrease of 24 percent. The combined labor costs for the on-the-rail plants are also listed Tables 9 and 10. The on-the-rail plants will subsequently be described as A, B, C, D, and E where hourly output per plant is 20, 40, 60, 75, and 120 head respectively.

INVESTMENT COSTS

By definition there are no fixed inputs for the firm in the long-run; however, there are investment requirements which are fixed costs in the short-run. Investment in this context is used to mean costs of land, buildings and improvements, and equipment -- items which are durable and remain useful longer than one production period. Investment does not appear as a lump sum in the cost records of a firm, but is spread over the useful life of the item concerned as depreciation. In addition, several other cost items -- insurance, taxes, and interest on investment are affected by the size and nature of the firm's investment. These costs then become an annual fixed cost facing the firm in the short-run.

Investment in Model Plants

Buildings

The costs of constructing a cattle slaughtering plant depend on many variables: The geographic location, topography of the plant site, type of building being constructed, and varying requirements of the state, local, or federal inspection services.

Cost rates applicable to the Los Angeles area were used as a basis for determining building expenses; however, discussions with architects and engineers indicate that there is little variation of such costs among the metropolitan areas of the state. Of course, as plants locate farther from the centers of the building trade, greater transportation costs for building materials will be incurred.

For this analysis, it is assumed that the buildings are located on a flat area, a situation facing many of the California packing plants. The model plants were also specified to come under federal inspection, thus being subject to federal restrictions on construction, layout, and equipment. Federal inspection is required for interstate shipment of meat and for meat sold to federal agencies, e.g., United States Army. Briefly, some of the major requirements stemming from federal inspection include the following: (1) use of building material which is impervious, easily cleanable, and resistant to wear and corrosion, (2) floor construction of either vitrified brick bonded with acid-resistant waterproof mortar and laid on a waterproof concrete base or thick, acid-resistant waterproof concrete, (3) interior walls of smooth, flat impervious material such as glazed brick, glazed tile, portland cement plaster, or other nontoxic, nonabsorbent material and, (4) window areas in unrefrigerated workrooms of about a fourth of the floor area of the workroom.

The Federal Meat Inspection Division also has established certain minimum distances between some operations and items of equipment. The more important of these standards are given in Appendix Table A-13.

In order to synthesize the building costs for various sizes of slaughter plants, engineering and architectural drawings of kill floors were obtained to which cost rates were applied (see Figures 5 and 6). In some cases, the drawings were modified in order to make the plants fall under the previous assumption of cattle kill only with no rendering. Plans for the two-bed conventional plant were obtained in detail for all operations (see Figure 6) and in some cases space from this plant was extrapolated to the other sizes. Kill floors were specified to be waterproof concrete.

In many existing plants, one of the major, if not the major limitation on production is the size of the chill and holding coolers. The chill

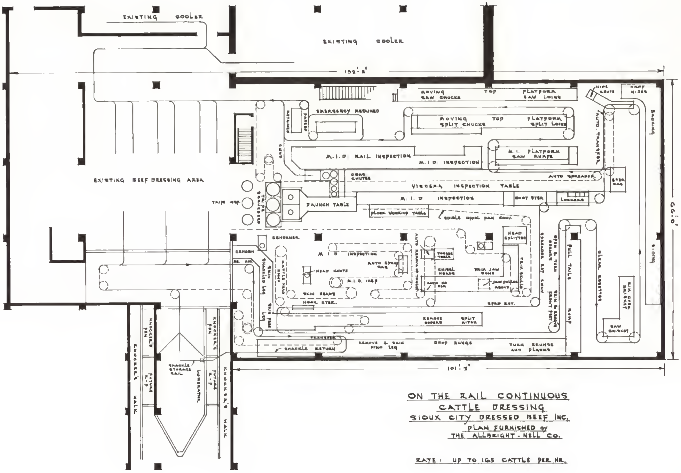


Figure 5: Architectural Floor Plan for On-the-Rail Plant Killing 120 Head per Hour.
(Courtesy of the Allbright-Nell Company, Chicago.)

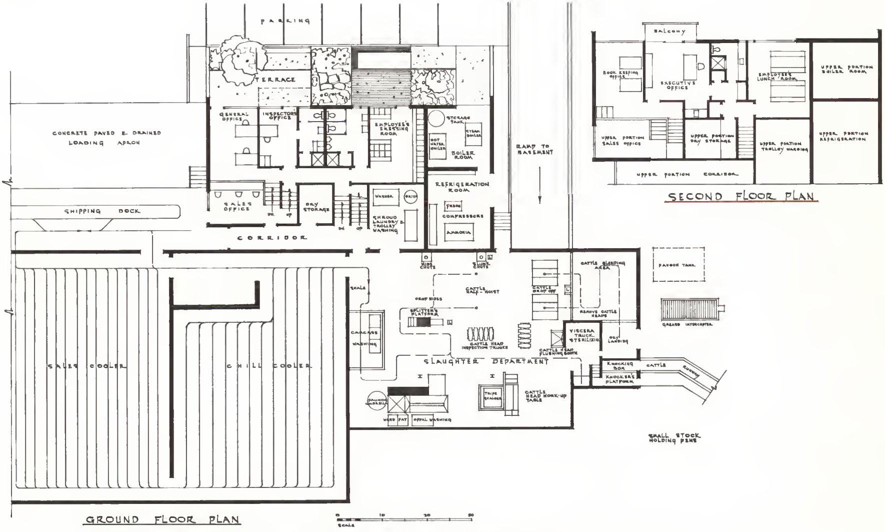


Figure 6: Architectural Floor Plan for Two-Bed Cattle Slaughtering Plant.

(Modified to include just cattle slaughter from a plan supplied by H. H. Olson & Associates, Los Angeles.)

cooler is the initial cooler in which the body heat of the freshly killed animal is removed; the holding cooler becomes a storage and aging room in which the carcasses are held for sale. Carcasses are generally held overnight in the chill cooler, and then two days in the holding cooler in California slaughtering plants. Therefore, the chill coolers for the model plants were designed to hold a number of carcasses equivalent to one day's kill, while the holding coolers were "constructed" to hold two days' kill. The kill figure used for each size of plant was the daily maximum for that particular size of plant. Two feet of rail space were allowed for each carcass, and the rails in the holding cooler were spaced 2 feet 6 inches apart with 3 feet after every third rail. Rails in the chill cooler were 3 feet apart.

After estimating the cooler space for the various plants, synthesized area in square feet was regressed against daily kill (since cooler capacity is a simple multiple of daily kill). The resulting function was:[1]

$$Y_1 = 584.554 + \underset{(.5623)}{19.815} X_1$$

where Y_1 = cooler space in square feet

X_1 = daily kill in number of head.

The coefficient of determination, r^2, was .9968.

A similar function was derived for office space requirements; however, the observations were those of actual plants. The square footage of office space, Y_2, was regressed against the number of office personnel including management, buyers, and sellers, X_2. The derived function was

$$Y_2 = 192.565 + \underset{(16.529)}{137.828} X_2$$

$$r^2 = .9586.$$

In estimating the space for employee dressing and eating rooms, a constant figure of 17 square feet per union employee -- obtained from the detailed plans for the two-bed plant -- was used as a slope with the function passing through the origin.

---

[1] Figures in parentheses are standard errors of estimated coefficients.

The plants were "built" with a basement loading dock for tripe and green hides. Thus the plant floor would have chutes and slides to convey the tripe, hooves, and hides to the dock area, eliminating the use of barrels on the kill floor.

The basement and storage areas were extrapolated from the two-bed plant on the basis of number of square feet per head of daily kill. Such extrapolation assumes, of course, that on-the-rail plants will not require proportionately more or less storage than the bed-type plants.

The equipment cleaning room area, used to wash and oil beef trolleys, was held constant at 224 square feet over all sizes of plants. Since the equipment used for this purpose is the same up to 800 trolleys an hour (6,000 a day), there would be little need for enlarging the cleaning room over the size of plants being considered.

Sizes of the boiler and refrigeration equipment rooms were derived from specifications by manufacturing concerns. For plants killing up to and including 300 head per day (40 per hour), the refrigeration rooms would be the same size, 12 feet by 20 feet. The remaining plants being studied (375 head through 900 head per day) would utilize a refrigeration room 20 feet by 40 feet. The fixed size of refrigeration rooms over various scales of plants results from the nature of the cooling equipment. The capacities and volumes of cooling equipment (such as compressors) increase much faster than the increase in physical dimensions; a large change in capacity, therefore, may require very little, if any, addition in floor space.

For the boilers, 3 feet were allowed on two sides of the boiler with 5 feet on the two ends. These allowances were then added to the dimensions of the boilers and the room space derived therefrom.

Carcass loading docks were assumed to extend along the longer side of the sales cooler, and were specified to be 10 feet wide for the one-bed plant and 15 feet wide for all other plants. For sanitary purposes, the loading dock was designated to be enclosed -- walled on all sides except for openings for loading trucks from the back end.

A concrete loading dock apron was specified to run the length of the dock and to extend 20 feet from the edge of the dock to meet federal regulations. Similarly a concrete ramp was "constructed" to allow truck loading of the tripe and hides from the basement dock. For a single basement loading dock (1 truck at a time) the ramp was 60 feet long by 15 feet wide. Single ramps were used for plants killing up to 262 head per day (35 per hour), while double ramps (60 feet by 30 feet) were used for plants killing from 262 head per day (35 head hourly) to those killing 562 head daily (75 head per hour). The plant with a kill rate of 900 a day (120 head per hour) was given a four-unit ramp (60 feet by 60 feet).

The cost rates for construction of slaughtering plants fall into five general categories: (1) kill floor, (2) cooler rooms, (3) office space, (4) dry storage (boiler, refrigeration, locker rooms), and (5) concrete flooring. Construction costs were taken from a published meat industry report and were verified by discussions with architects and industrial engineers in the Los Angeles area. The figures are found in Table 11.

The cost rates shown in Table 11 were applied to the various floor area requirements from the plans used. The results are found in Tables 12 and 13.

Slaughter plant architects and engineers reported that the lower limits of the cost range generally apply to larger plants, with the costs of the small one-bed plant and Plant A approaching the upper limit. Therefore, the upper cost limits were used for the two small plants and the lower limits used for the larger plants. This procedure assumed pecuniary economies of construction, but it appears to be more realistic than using the same square footage cost for all sizes of plants.

Corral

In addition to the building which houses the killing and cooling operations, the holding pens (or corral facilities) are a major building

TABLE 11

Costs Per Square Foot of Constructing Cattle Slaughtering Plants[a]

Description	Cost per square foot
	dollars
Kill floor	18.00-25.00
30 degree cooler or refrigeration work area	15.00-20.00
Dry storage area	6.00-10.00
Office space	10.00-12.00
Waterproof concrete flooring alone	2.75- 4.00

[a] Figures for all but office space were taken from Meat Industry Trends, 1961, Ed. H. L. Rothra, Chicago: Meat Magazine, 1961, pp. 1-7. These figures were verified for the Los Angeles area by architects and engineers from that region.

TABLE 12

Building Requirements and Costs for Conventional Plants

Building area	Building cost per square foot	Conventional plants with					
		One-bed		Two-bed		Three-bed	
		Floor area	Total cost	Floor area	Total cost	Floor area	Total area
	dollars	sq.ft.	dollars	sq.ft.	dollars	sq.ft.	dollars
Kill floor	18.00-25	1,841	46,025	2,701	48,618	3,706	66,708
Chill and offal cooler	15.00-20	1,276	25,520	2,301	34,515	3,225	48,375
Sales cooler	15.00-20	1,887	37,740	3,363	50,445	4,650	69,750
Office	10.00-12	1,020	12,240	1,900	19,000	2,536	25,360
Employee dressing a/	6.00-10	b/		673	4,038	969	5,814
Equipment clean-up c/	6.00-10	224	2,240	224	1,344	224	1,344
Refrigeration	6.00-10	500	5,000	304	1,824	800	4,800
Boiler	6.00-10			240	1,440	384	2,304
Dry storage	6.00-10	552	5,520	200	1,200	286	1,716
Basement	6.00-10	524	5,240	1,080	6,480	1,546	9,276
Dock	15.00-20	224	4,480	720	10,800	840	12,600
Dock apron	2.75- 4	560	2,240	960	2,640	1,120	3,080
Ramp	2.75- 4	900	3,600	900	3,600	1,800	7,200
TOTAL		9,508	149,845	15,566	185,944	22,086	258,327

a/ Based on 17 sq. ft. per union employee.

b/ Included in dry storage area.

c/ Constant over all the plants.

Source: Column 1 - Taken from Table 11.
Columns 2, 4, 6 - See text for a discussion of the method of synthesizing the various building components.
Column 3 - Column 2 times the upper limit in column 1.
Columns 5 and 7 - Columns 4 and 6 respectively, times the lower limit in Column 1.

TABLE 13

Building Requirements and Costs for On-The-Rail Plants

Building area	Building cost per square foot	On-the-rail plants									
		A		B		C		D		E	
		Floor area	Total cost	Floor area	Total cost	Floor area	Total cost	Floor area	Total cost	Floor area	Total cost
	dollars	sq.ft.	dollars	sq.ft.	dollars	sq.ft.	dollars	sq.ft.	dollars	sq.ft.	dollars
Kill floor	18.00-25	1,230	30,750	3,219	57,942	5,142	92,556	5,234	94,212	8,084	145,512
Chill and offal cooler	15.00-20	1,513	30,260	2,672	40,080	3,654	54,810	4,805	72,075	7,551	113,265
Sales cooler	15.00-20	2,147	42,940	4,092	61,380	5,796	86,940	6,915	103,725	10,867	163,005
Office	10.00-12	1,157	13,884	2,122	21,220	2,949	29,490	3,363	33,630	4,741	47,410
Employee dressing[a]	6.00-10	442	4,420	850	5,100	1,139	6,834	1,326	7,956	2,006	12,036
Equipment clean-up[b]	6.00-10	224	2,240	224	1,344	224	1,344	224	1,344	224	1,344
Refrigeration	6.00-10	240	2,400	240	1,440	800	4,800	800	4,800	800	4,800
Boiler	6.00-10	200	2,000	372	2,232	442	2,652	476	2,856	540	3,240
Dry storage[c]	6.00-10	150	1,500	229	1,374	344	2,064	429	2,574	687	4,122
Basement[c]	6.00-10	618	6,180	1,237	7,422	1,855	11,130	2,317	13,902	3,710	22,260
Dock	15.00-20	430	8,600	990	14,850	1,350	20,250	1,672	25,080	1,725	25,875
Dock apron	2.75- 4	860	3,440	1,320	3,630	1,800	4,950	2,230	6,132	2,300	6,325
Ramp	2.75- 4	900	3,600	1,800	7,200	1,800	7,200	1,800	7,200	3,600	14,400
TOTAL		10,111	152,214	19,367	225,214	27,295	325,020	31,591	375,486	46,852	563,594

a/ Based on 17 sq. ft. per union employee.
b/ Constant over all plants.
c/ Extrapolated from two-bed plant on the basis of kill per day.
Source: Column 1. Taken from Table 11.
Columns 2, 4, 6, 8, and 10. See text for a discussion of the method of synthesizing various building components.
Column 3. Column 2 times the upper limit in column 1.
Columns 5, 7, 9, and 11. Columns 4, 6, 8, and 10 respectively, times the lower limit of column 1.

cost item. Plants surveyed showed a large variation in the quantity of animals (in terms of a day's kill) that could be kept in the holding pens. Standards set by the Meat Inspection Division of the federal government rule that the pens shall have a capacity of at least one day's maximum kill. However, none of the capacities of plants surveyed was less than 1.9 times the day's kill rate, and most were over that figure.

For purposes of this study, it was specified that the plant would maintain holding pens for a number of animals approximately 2.5 times the daily kill rate. In this manner, the firm could maintain a steady kill rate, but still be able to cope with daily fluctuations in the supply of live animals.

The federal restrictions also instructed that "pens, ramps, unloading chutes, and runways must be paved with concrete or brick and, except at gateways, have side curbs of similar impervious material 12 inches or more in height and suitable drainage facilities."1/

The pens were designed to be concrete, 10 feet by 20 feet, holding 11 head per pen. This allows 18 square feet per animal.2/ The alleys or runways were assumed also to be concrete, 10 feet wide. Fencing for most holding pens is made of wood, with heights up to 6 feet.3/ The gates used in this study were 10-foot swinging gates.

The cost rate used in deriving construction costs of the concrete floors for the pens and runways was the lower rate ($2.75 per square foot) listed in Table 11 for waterproof concrete flooring. Fence costs, based on rates quoted by fencing concerns, were $2.25 per linear foot for a 6-foot wood fence, while the cost of the 10-foot swinging gate was $45.00 each.

Area requirements for the holding pens, the linear requirements for the fencing, and the total costs of the synthesized corrals are given in Table 14.

1/ U. S. Inspected Meat Packing Plants, op. cit., page 14.

2/ See Hammons and Miller, op. cit., page 34.

3/ Miller, Jarvis E., and Donald R. Hammons, Independent Meat Packing Plants in Texas. Texas Agricultural Experiment Station Bulletin MP-306, College Station, Texas, September 1958, page 12.

TABLE 14

Cost of Corrals and Corral Fencing

Plant	Holding pens 20' x 10'	Area in pens	Area in alleys	Total area	Cost of corrals, alley floor	Gates	Length of fencing	Cost of gates, fencing	Total cost
	number	square feet			dollars	number	feet	dollars	
Conventional:									
One-bed	29	5,828	1,985	7,813	21,485.75	28	957	3,413.25	24,899.00
Two-bed	61	12,228	3,585	15,813	43,485.75	60	1,817	6,788.25	50,274.00
Three-bed	85	17,028	4,785	21,813	59,985.75	84	2,477	9,353.25	69,339.00
On-the-rail:									
A	35	7,028	2,285	9,313	25,610.75	34	1,107	4,020.75	29,631.50
B	69	13,828	3,985	17,813	48,985.75	68	2,037	7,643.25	56,629.00
C	103	20,628	5,685	26,313	72,360.75	102	2,977	11,288.25	83,649.00
D	129	25,828	6,985	32,813	90,235.75	128	3,687	14,055.75	104,291.50
E	205	41,028	10,885	51,913	142,760.75	204	5,777	22,178.25	164,939.00

Source: Column 1. Based on 11 head per pen with total capacity of approximately 2-1/2 days kill.
Column 2. Number of pens in column 1 less 3, multiplied by 200 square feet per pen, plus 628 square feet in two large end pens.
Column 3. Alleys are specified as 10 feet wide.
Column 4. Column 2 plus column 3.
Column 5. Column 4 times $2.75 per square foot.
Column 6. The number of gates is one less than the number of pens since the two larger end pens are the equivalent of 3 pens of size 10 feet by 20 feet.
Column 7. Derived from pen requirements.
Column 8. Fencing is assumed to cost $2.25 per linear foot, gates (10 feet wide) are assumed to cost $45.00 each.
Column 9. Column 5 plus column 8.

A linear function was estimated statistically from the synthesized corrals to specify the square footage needed for various capacities of holding pens.

This function derived was

$$Y_3 = 758.873 + \underset{(.0614)}{22.702}X_3$$

$$r^2 = .9999$$

where Y_3 = total square footage
X_3 = total number of cattle in pens.

Similarly, a function for fence construction was estimated with the following coefficients:

$$Y_4 = 172.462 + \underset{(.0087)}{2.484}X_3$$

$$r^2 = .9999$$

where Y_4 = total footage of fencing required
X_3 = total number of cattle in pens.

Land

A definite policy concerning land requirements was not found in the observed plants. Of course, the feasibility of obtaining more land area than is needed for the building and corrals will depend to a large extent upon the development of the area immediately surrounding the slaughter plant. In a heavily developed, high-cost industrial district, for example, a slaughtering firm would in all likelihood obtain only enough land to supply room enough for buildings and corrals. In other areas, the firm might purchase extra land for possible future expansion.

For this study, the land investment was considered to include only the area needed for buildings and corrals. Additional costs for driveways, employee parking, and lawns would increase the total cost, but were not included in this study.

A rate of $0.50 per square foot of land, based on market values of land supplied by the Los Angeles County tax office, was used to calculate the land investment. The estimated investment figures may be found in Table 15.

Equipment

Current value of equipment may bear little resemblance to the original value of equipment found in accounting records of individual firms because of inflationary or deflationary price changes, or cost-reducing changes in the technology of manufacturing such equipment.

For these reasons, equipment requirements for the model plants were synthesized. The physical requirements for conventional plants were based on observations and itemized equipment breakdowns from actual plants. For the on-the-rail plants, major equipment needs were taken from a manufacturer's specifications of actual plants. Equipment common to on-the-rail and conventional bed-type plants which was not included in the manufacturer's specifications was inserted in the equipment list.

The equipment investment includes the costs of the items, freight charges for shipment from manufacturer to packing plant, plus a 4 percent sales tax (see Appendix Table A-14). Equipment costs were taken from prices quoted by meat packing equipment manufacturers and include charges for installation. Shipping was assumed to be done via motor truck.

The weight in all cases for outfitting the complete plant was great enough to fall under the lowest freight rate. The on-the-rail equipment originated in Chicago and moved to Los Angeles, and shipment for conventional plants went from San Francisco to Los Angeles. At the time of this study, there was only one major equipment manufacturer on the West Coast; major on-the-rail equipment makers were centered in Chicago and Cincinnati.

The equipment items specified for the various plants, their use life, and weight per unit are listed in Appendix Tables A-15 and A-16. A few

TABLE 15

Cost of Land Areas for Synthesized Plants

Plant	Building area	Corral area	Total land area	Cost of land
	square feet			dollars
Conventional:				
One-bed	9,508	7,813	17,321	8,660
Two-bed	15,566	15,813	31,379	15,690
Three-bed	22,086	21,813	43,899	21,950
On-the-rail:				
A	10,111	9,313	19,424	9,712
B	19,367	17,813	37,180	18,590
C	27,295	26,313	53,608	26,804
D	31,591	32,813	64,404	32,202
E	46,852	51,913	98,765	49,382

Source: Column 1. Tables 12 and 13.
Column 2. Table 14.
Column 3. Column 1 plus column 2.
Column 4. Column 3 times $.50 per square foot.

comments on some of the individual items for clarification may be needed at this point.

Refrigeration and boilers.--Specifications on cooler refrigeration were made by an engineering specialist of a refrigeration manufacturing company. The costs used for the refrigeration are "averages" based on previous installations and may be affected by construction details, insulation, location, type of control desired (automatic or manual) use of high speed (light duty) or vertical slow speed (heavy duty long service) compressors.[1]

Boiler requirements and costs also were derived from manufacturing information based on previous installations at slaughtering plants. Since hot water usage was limited to the "clean-up" routines of carcass washing, tripe and offal work-up, and the cleaning of buildings and equipment, boiler horsepower was considerably less than for plants with rendering, sausage making, or similar operations.

Boiler horsepowers for plants with capacities of 10-, 35-, 60-, and 120-head per hour were estimated by boiler engineers. From these estimations (15, 35, 50, and 100 horsepower, respectively), a simple linear function was derived relating horsepower to daily kill which was used to estimate boiler needs for the model plants. The estimated function was:

$$Y_5 = 6.982 + .102X_1$$

$$r^2 = .9884$$

where Y_5 = boiler horsepower

X_1 = daily kill in number of head.

Since boilers are often made in discrete steps of horsepower instead of continuous quantities (unless custom built) the predicted requirements for the eight plants were rounded to the nearest number divisible by five.

---

[1] Correspondence of H. J. Smith, Cyclops Iron Works, San Francisco, with S. H. Logan, December 1961.

Pumps.--Two types of pumps are generally utilized in packing plants: a pressure pump used to pump water for carcass washing and a solids pump used for pumping water containing solid material such as paunch manure, fat scraps, and corral wastes. The size of the pressure pump was determined by the amount of water required per minute for washing carcasses -- approximately 50 gallons of water at 200 pounds of pressure for each carcass.[1] A small plant killing 17 head per hour would use 850 gallons per hour or an average of 14.1 gallons of water a minute under pressure. Other hourly rates of kill and the associated average rates of water consumption per minute for carcass washing are: 35 head, 29.1 gallons; 50 head, 41.7 gallons; 20 head, 16.7 gallons; 40 head, 33.3 gallons; 60 head, 50.0 gallons; 75 head, 62.5 gallons; and 120 head, 100.0 gallons.

Pressure pumps are multistage, electrical drive pumps with each stage capable of pumping 20 gallons of water a minute at 200 pounds of pressure. Such step increases in capacity mean that the same capacity pump may be used by more than one plant, a factor which provides some economies to larger plants using the same pump as smaller plants.

The solids pumps are specified to have 3-inch solids capacities, meaning that the pumps can handle solids up to 3 inches in diameter. For plants killing 40 head per hour or less, the same pump is used with only the horsepower of the motor varying. This pump at full capacity is capable of pumping 300 gallons a minute, and utilizes 7.5 horsepower. For plants killing 17 and 20 head per hour with pumping requirements of less than 100 gallons a minute, the horsepower is cut to 3 or 4.

For plants killing more than 40 head per hour, it is more economical to switch to a 4-inch pump capable of pumping 500 gallons a minute than to use a heavier pump with a 3-inch capacity. For 75 head per hour, 2 pumps are used, and for 120 head, 3 pumps are specified. The size of the pump needed was estimated by calculating the water usage per minute of each plant, a procedure which admittedly results in some over-capacity of the pump since not all of the water consumed will flow through the solids pump.

---

[1] Dillon, C. E., Meat Slaughtering and Processing, St. Louis: Meat Merchandising, Inc., 1947, page 30.

Blood tanks.--The blood from the animals traditionally is drained into a large tank from which it is either processed at the slaughter plant or picked up by a processing firm. With the previous assumptions the latter case would prevail here. Smaller plants may utilize a blood tank -- a large cylindrical storage container -- with a capacity of all the blood from a day's kill. Larger plants, however, often require draining of the tank two or three times daily.

To calculate the size of the tank needed, a blood production per animal of approximately 42 pounds or 5.6 gallons of blood was used.[1] The daily blood production and the specified size of blood tank for each plant is found in Appendix Table A-17.

Cooler railing.--The specifications for railing space per head have been explained elsewhere (see the section on building requirements) and will not be repeated here. A linear function was estimated for the railing requirements, however, from the synthesized plants with the resulting coefficients:[2]

$$Y_6 = -92.516 + \underset{(.301)}{2.249}X_4$$

$$r^2 = .9331$$

where Y_6 = cooler rail in feet

X_4 = number of head to be kept in coolers.

The hangers associated with any given footage of railing are calculated by dividing the rail footage by 2.3; a ratio used by equipment manufacturing concerns.

---

[1] Swift & Company, op. cit.

[2] Admittedly, one would not expect a negative intercept. In this case, the apparent diseconomy was due to lack of uniformity in the architectural layouts for the cooler. For example, a long, narrow cooler would require more side railing along the walls than would a short, wide cooler. This side rail is used to move carcasses to the storage rail, but is not used as a storage rail itself. Thus, with coolers for larger plants being laid out in the former design and the smaller plant coolers being of the latter nature, diseconomies or a negative intercept could well result.

Other equipment.--A few other special items deserve comment in way of explanation of their selection over other alternatives. In the conventional plants, a power dropper was utilized to lower the animal from the bleeding rail to the floor instead of a friction dropper; the former enables the operator to rehoist the carcass if it does not rest properly on the cradle bars.

Trolleys for both conventional and on-the-rail plants were allocated on the basis of four days' kill. Three days' kill is hanging in the cooler or in trucks at any given time and trolleys for the immediate day's kill would fill out the total number of trolleys needed.

One locker was provided for each union employee and each inspector for each plant in accordance with federal regulations.[1/]

As evidenced from Appendix Table A-16, the larger on-the-rail plants change technology with respect to moving the carcass along the rail. Small on-the-rail plants utilize an intermittent drive conveyor for the dressing operations with "drop rail" sections for eviscerating and splitting. Plants killing 60, 75, and 120 head per hour, however, utilize continuous conveyors with a moving-top viscera table. These plants also use a head and tongue conveying system (hooks on a moving chain) instead of head inspection racks. The conveyor system takes the heads to the washer, head work table and head splitter.

Finally, for the large kill rate of 120 head per hour, an additional continuous conveyor is used in the bleeding, the washing, and shrouding operations.

Total equipment costs.--Sales costs and freight costs specified for the synthesized plants are given in Table 16. Individual prices were not listed at the request of the manufacturing concerns supplying the cost data. The annual costs associated with investment in buildings, land, and equipment will now be considered.

[1/] U. S. Inspected Meat Plants, op. cit., page 32.

TABLE 16

Equipment and Depreciation Costs for Synthesized Plants

Plant	Cost of equipment	Freight costs	Salvage value	Balance for depreciation (office)	Balance for depreciation (total)	Total depreciation per year	Depreciation per head
	dollars						
Conventional:							
One-bed	66,164	268	5,044	2,803	64,035	5,853	.18
Two-bed	105,790	383	8,033	4,954	102,125	9,627	.15
Three-bed	137,049	535	10,200	6,486	133,000	12,477	.13
On-the-rail:							
A	107,088	1,872	7,859	2,979	105,385	8,428	.22
B	154,569	2,467	11,384	5,750	151,834	12,687	.17
C	248,793	5,852	18,220	9,132	246,456	19,998	.18
D	285,804	6,398	20,824	9,439	282,889	23,034	.16
E	415,430	11,027	28,630	15,026	414,933	32,510	.14

Source: Column 1. Derived on the basis of manufacturers' prices plus installation fees, excluding sales tax.
Column 2. Derived from the freight rates in Table A-14 and the weights of the various equipment items given in Tables A-15 and A-16.
Column 3: Derived from estimates of salvage values for various items of equipment.
Column 4. Balance includes (sales cost plus installation costs plus 4 percent sales tax plus freight costs) minus salvage value.
Column 6. Total of yearly depreciation of the various equipment items, calculated by dividing the balance for depreciation of each item by its estimated use life.
Column 7. Column 6 divided by the yearly kill of each plant.

Annual Costs of Investment

Five major cost items emanate from the investment of the firm: (1) depreciation of equipment and improvements, (2) insurance, (3) property taxes, (4) interest charges, and (5) repair and maintenance, a factor which depends on the quantity and nature of the machinery and buildings and also on the amount of usage made of these items. Repair and maintenance will be considered, however, under costs of "Miscellaneous Supplies and Services."

Depreciation

The depreciation of a durable asset can be divided into (1) depreciation from wear and usage, (2) depreciation over time resulting from age, and (3) depreciation due to obsolescence. Unfortunately, the empirical separation of depreciation into these components is a highly formidable, if not an impossible, task. To know depreciation from obsolescence would be to know future developments in technology. Similarly, little in the way of empirical data is available to extract the depreciation from usage from that of age. And such separation would seem to serve little value in light of the desired results of this study.

Therefore, the depreciation cost for the equipment was calculated as follows (a procedure common to many slaughter houses): (1) the total cost of the goods, including sales cost, installation charges, freight charges, and sales tax, was calculated for each item, (2) the estimated salvage value of the item was subtracted from the cost to obtain the balance for depreciation, and (3) the balance for depreciation was divided by the estimated use life of the item.

Salvage value was estimated with a heavy reliance on practices of actual plants. For items for which salvage values were generally applicable, such value was taken to be a flat 10 percent of the original sales price (not including installation).

The use life of equipment is often concerned with factors other than just the actual expected life of the goods.1/ Although firms may write

---

1/ Rogers, George B., and E. T. Bardwell, Marketing New England Poultry. 2. Economies of Scale in Chicken Processing, University of New Hampshire, Agricultural Experiment Station Bulletin No. 459, April 1959, page 12.

off the investment before its actual use life has expired, such a policy inherently would seem to include depreciation resulting from expected obsolescence and should tend to reflect the various depreciation components in one total figure.

Therefore, the expected use life of the item was gleaned from the accounting data of the firms studied. Generally, there was close agreement on like items among the firms, but where discrepancies arose, a modal value was used whenever possible.[1]

A simple straightline depreciation policy was followed. The total construction costs of buildings and corrals are given in Table 17. In addition to the total construction costs, a flat 5 percent fee was charged for architectural services, based on costs quoted by Los Angeles architects.

The use life of most slaughter house buildings observed varied between 20 and 30 years, with most concerns using a 25-year figure, a level used to calculate the depreciation costs in this study. Total depreciation costs for improvements are listed also in Table 17. The depreciation costs for the equipment investment are given in Table 16.

On a per head basis, the depreciation costs show economies of scale both for the conventional and on-the-rail systems, with costs of $0.18 for the one-bed plant and $0.13 for the two- and three-bed plants. For on-the-rail plants, the depreciation costs decrease from $0.22 per head for 20 head per hour to $0.15 for 120 head per hour. However, the per head cost shows a jump to $0.18 per head from $0.16 per head as the kill rate goes from 40 head to 60 head per hour. This apparent diseconomy is attributable to the change in equipment requirements (and production function) as the larger plant uses a moving-top viscera table and more conveying systems.

---

[1] The use life figures given in Tables A-15 and A-16 which were taken from accounting records of the firms studied compare favorably with the estimated use life of packing plant equipment published by the U.S. Treasury Department, Bureau of Internal Revenue in Bulletin "F," revised January 1942, Income Tax Depreciation and Obsolescence Estimated Useful Lives and Depreciation Rates, Washington, D.C., 1948, pp. 55-56.

TABLE 17

Building Costs and Annual Depreciation for Synthesized Slaughter Plants

Plant	Building, corral architectural costs	Depreciation per year
	dollars	
Conventional:		
One-bed	183,481	7,339
Two-bed	248,029	9,921
Three-bed	344,049	13,762
On-the-rail:		
A	190,938	7,638
B	295,935	11,837
C	429,102	17,164
D	503,767	20,151
E	764,960	30,598

Source: Column 1. Tables 12, 13, and 14.
Column 2. Column 1 divided by 25 years.

Taxes

Of concern in this part of the study are personal property taxes assessed at the county level and applicable to land, buildings and other improvements, and equipment. Tax rates for Los Angeles County for the year 1960-61 were applied to the synthesized plants. The total rate used (taken from Los Angeles County Code Area No. 4) was $8.0964 per $100.00 of assessed valuation.[1/] Included in this rate is an assessment of $.3539 for county flood control which applies only to land and improvements. Therefore, a lower rate of $7.7425 per $100.00 of assessed valuation was used for the equipment.

The assessed valuation to which the tax rates are applied is usually some percentage of the actual market value of the property in question. Tax assessors in Los Angeles County reported the following "average" percentages of replacement value at which property is usually assessed: land, 25 percent; improvements, 33 percent; and equipment, 45 percent.

Application of the tax rate to the full assessed valuation, however, would be misleading as an indicator of average costs. As the equipment becomes older, its actual market value and assessed value decline. In order to estimate the tax costs facing the firm, a tax rate equal to half the regular rate was applied to the assessed value of the depreciable property. Such a tax cost then would show the charges at the half life of the equipment on the depreciable balance, assuming a straight line depreciation policy, and would be the average cost paid by the firm for property taxes over the life of investment.

Land is not generally depreciated, and for this reason the full tax rate applied to the investment price every year. A similar situation arises with respect to the salvage value of the equipment. This value does not depreciate from year to year, and hence the full rate would again be applicable to the assessed salvage value.

[1/] Byram, H. L., Tax Rates by Code Areas for the Fiscal Year 1960-61, Los Angeles, County Tax Collector, page 6.

The yearly tax costs of the various items and the total charge for taxes are given in Table 18.

Insurance

Factors such as the exposure of various sides of the building, accessibility, and building construction may all affect the cost of the insurance on a given equipment and building investment. In this study an insurance cost of $1.00 per $100.00 market or replacement valuation per year was used. While such insurance may be extended to cover the stock (both live and dressed), it was specified here to cover only the equipment and the buildings.

An average cost equal to $0.50 per $100.00 of the depreciable balance was used to estimate the average yearly insurance costs, thus reflecting the yearly decline in the market value of the items insured. Insurance on the salvage value of the equipment, however, was estimated at the full rate of $1.00 because of the nondepreciating nature of the salvage value.

Insurance costs per year for the various synthesized plants may be found in Table 19.

Interest

Although it is not generally found in most accounting records of the slaughtering plants (or other businesses for that matter), interest foregone on the money invested is also a cost facing the firm. An interest rate of 6 percent was used as the base rate applicable to the nondepreciating land investment and salvage value of the equipment, and a 3 percent figure was applied to the depreciable balance of the equipment and buildings.

The interest charges which were estimated for the slaughtering plants are listed in Table 19.

TABLE 18

Annual Personal Property Tax Costs for Synthesized Plants

Plant	Assessed land value	Taxes on land	Assessed improvements value	Taxes on improvements	Assessed equipment value	Taxes on equipment	Assessed salvage values	Taxes on salvage value	Total tax cost
	dollars								
Conventional:									
One-bed	2,165.00	175.29	57,665.52	2,334.42	28,815.75	1,115.53	2,269.84	175.74	3,801
Two-bed	3,922.38	317.57	77,951.94	3,155.65	45,956.38	1,779.09	3,614.90	279.88	5,532
Three-bed	5,487.50	444.29	108,129.78	4,377.31	59,850.00	2,316.94	4,590.00	355.38	7,494
On-the-rail:									
A	2,428.00	196.58	60,009.18	2,429.29	47,423.12	1,835.87	3,536.50	273.81	4,736
B	4,647.50	376.28	93,008.19	3,765.16	68,325.49	2,645.05	5,122.87	396.64	7,183
C	6,701.00	542.54	134,860.77	5,459.43	110,905.27	4,293.42	8,198.81	634.79	10,930
D	8,050.50	651.80	158,326.41	6,409.37	127,300.20	4,928.11	9,370.86	725.54	12,715
E	12,345.62	999.55	240,415.89	9,732.52	186,719.64	7,228.38	12,883.68	997.52	18,958

Source: Column 1. Twenty-five percent of actual market value in Table 15, column 4.
Column 2. A tax rate of 8.0964 per $100.00 of the assessed valuation in column 1 was used.
Column 3. Thirty-three percent of the actual market value (Table 12 and 13 plus Table 14).
Column 4. A rate equal to one-half the tax rate (0.5 times 8.0964 equals 4.0482) per $100.00 valuation was applied to column 3.
Column 5. Forty-five percent of the actual market value in Table 16.
Column 6. Only 7.7425 of the full tax rate of 8.096 is applicable to equipment. A rate equal to half this rate (3.87125) was applied to the assessed value of the balance for depreciation in column 5.
Column 7. Forty-five percent of actual value.
Column 8. The tax rate of 7.7425 was applied to the assessed salvage value of the equipment in column 7 since this figure is assumed not to depreciate over the life of the equipment.
Column 9. Column 2 plus column 4 plus column 6 plus column 8.

TABLE 19

Charges for Interest and Insurance on Investment for Synthesized Plants

Plant	Investment in building and equipment	Interest charges	Land investment and salvage value for equipment	Interest charges	Total interest charges	Insurance on investment	Insurance on fixed salvage value	Total insurance costs
	dollars							
Conventional:								
One-bed	240,908	7,227	13,704	822	8,049	1,204	50	1,254
Two-bed	338,343	10,150	23,723	1,424	11,574	1,692	80	1,772
Three-bed	460,666	13,820	32,150	1,929	15,749	2,303	102	2,405
On-the-rail:								
A	287,231	8,617	17,571	1,054	9,671	1,436	79	1,515
B	433,677	13,010	29,974	1,799	14,809	2,168	114	2,282
C	655,125	19,654	45,023	2,701	22,355	3,276	182	3,458
D	762,666	22,880	53,026	3,182	26,062	3,814	208	4,022
E	1,143,466	34,304	78,013	4,681	38,985	5,718	286	6,004

Source: Column 1. Investment costs from Tables 12 and 13 plus 14, plus Table 16.
Column 2. Three percent of column 1.
Column 3. Table 15 plus Table 16.
Column 4. Six percent of column 3.
Column 5. Column 2 plus column 4.
Column 6. \$.50 times $\frac{\text{column 1.}}{100}$
Column 7. \$1.00 times $\frac{\text{Table 16 column 3}}{100}$.
Column 8. Column 6 plus column 7.

COSTS OF UTILITIES, MISCELLANEOUS SUPPLIES AND SERVICES

There are many inputs such as shrouds, neck skewers, invoices, wrapping paper, and rifle shells whose costs individually are relatively small, but when combined into various categories their collective costs become important items. These categories include the costs of utilities and non-labor costs of repair and maintenance, killing supplies, office supplies, taxes and licenses (other than personal property taxes), telephone, delivery and selling, feed and corral, and buying. As will be discussed below, the physical requirements for the various utilities for a given plant were considered fixed in the short-run, whereas the miscellaneous cost items were variable. With the exception of the use of natural gas, the cost items either exhibited little basis by which they could accurately be synthesized, or were of such a numerous nature as to make synthesis infeasible from both a time and financial standpoint. In these cases, accounting data obtained from the slaughtering plants surveyed were used to estimate statistical functions from which costs could be calculated. In some cases, the nonhomogeneous nature of the data prevented regression analysis; use then was made of a mean or modal figure.

Utilities

Costs of heating, lighting and power, and water are each important cost items, and were studied separately. Actual plants exhibited variation with regard to heating techniques. Generally, the plants operated with natural gas, and such was specified to be the case for this study. Similarly, it was assumed that water should be purchased from a local water department. Electricity in all cases observed was purchased from the local branch of a power company.

Functions were derived relating the consumption of water and electricity in physical units (hundred cubic feet for water and kilowatt-hours for electricity) to the number of animals killed. Data from various California slaughter houses indicated that short-run variations (month-to-month changes) in output seemed to have little effect on the use or demand for utility inputs. Some lack of variation might be expected *a priori* for much of the lighting and for a small amount of the power requirements due to constant leakage of cold air through doors and walls. A more definite relationship between output and consumption of electricity and water was found with the yearly data. Such a relationship should exhibit more accurately the long-run requirements for these inputs. In the short-run, monthly usage of utility inputs would be relatively unaffected by month-to-month variations in output.

Electricity

A simple linear function was estimated relating the yearly consumption of electricity for lighting and power to the number of head of cattle slaughtered. The observed data and the estimated function is shown in Figure 7, Section A. The function had the following coefficients:

$$Y_7 = 157183.647 + 15.448X_5$$

$$r^2 = .8294$$

Where Y_7 = yearly consumption of electricity in kilowatt-hours

X_5 = yearly slaughter in number of head.

The electrical rates used were taken from the rate schedules for general service of the Southern California Edison Company Los Angeles.1/

1/ Electrical rates taken from Schedule A-7 General Service of Southern California Edison Company, Los Angeles, effective January 15, 1958.

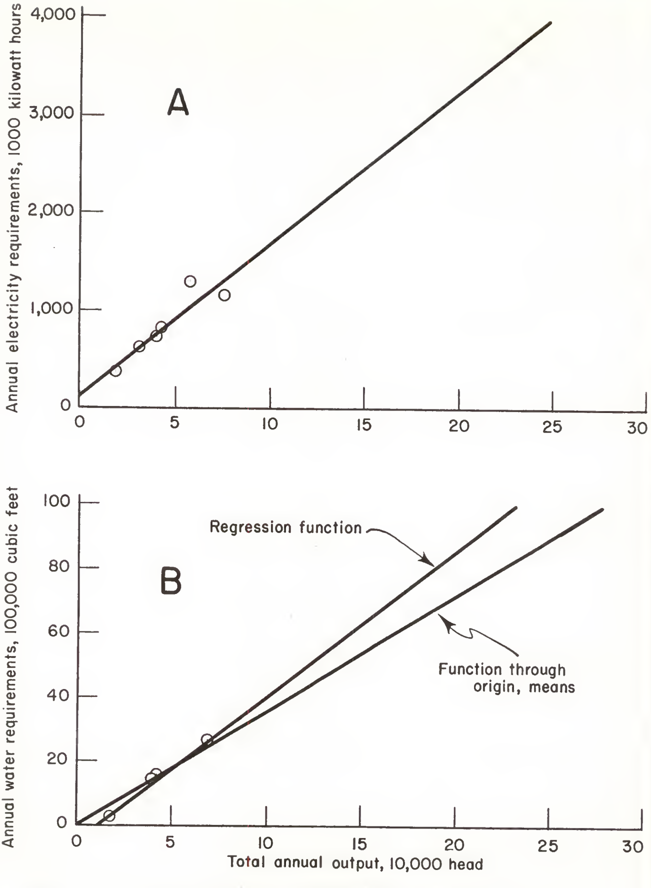


Figure 7. A. Annual Electricity Requirements as a Function of Yearly Output
B. Annual Water Requirements as a Function of Yearly Output

The rate charge was as follows:

Demand Charge	Per Month
First 75 kw or less of billing demand	$85.00 per meter
Next 125 kw of billing demand	0.95 per kw
Next 1,800 kw of billing demand	0.85 per kw
Next 8,000 kw of billing demand	0.75 per kw
Next 40,000 kw of billing demand	0.60 per kw
All excess kw of billing demand	0.55 per kw

Energy Charge (to be added to demand charge)	
First 150 kwhr per month per kw of billing demand	
First 15,000 kwhr per month	1.9 cents per kwhr
Balance of kwhr per month	1.0 cents per kwhr
Next 150 kwhr per month per kw of billing demand	0.8 cents per kwhr
All excess kwhr per month per kw of billing demand	0.6 cents per kwhr

The billing demand was derived for the various plants on the basis of the rule of thumb used by the electrical concerns that the billing demand is equal to approximately 4 kilowatts for every 1,000 kilowatt-hours consumed.

The electrical requirements and the costs thereof are given in Table 20.

Water

As explained previously, usage of water centers principally around "cleaning" or washing operations.[1] However, additional operations such as rendering and sausage-making in many of the actual plants studied made the data regarding water usage unacceptable for statistical analysis since these operations require large amounts of water for steam processing and cleaning.

Data from four plants were used to derive a linear function relating yearly water consumption in 100 cubic feet (Y_7) to yearly slaughter in number of head (X_5). The resulting function was:

$$Y_8 = -3736.127 + \underset{(0.33)}{.450X_5}$$

$$r^2 = .9894.$$

---

[1] The costs allocated to water in this case implicitly include charges for sewage disposal. For plants located in sparsely populated areas additional costs of sewage treatment and disposal might be incurred.

TABLE 20

Annual Electrical Requirements and Costs for Synthesized Plants

Plant	Yearly electrical requirements	Average monthly electrical requirements	Billing demand per month	Demand charge	Energy charge	Total monthly electrical costs	Yearly total electrical costs
	kwh		kw	dollars			
Conventional:							
One-bed	651,581	54,298	217	218.20	634.48	852.68	10,232.00
Two-bed	1,177,122	98,094	392	366.95	1,037.35	1,404.30	16,852.00
Three-bed	1,617.020	134,751	539	491.90	1,374.71	1,866.61	22,399.00
On-the-rail:							
A	741,118	61,760	247	243.70	703.18	946.88	11,362.00
B	1,325,052	110,421	442	409.45	1,150.97	1,560.42	18,725.00
C	1,908,987	159,082	636	574.35	1,598.46	2,172.81	26,074.00
D	2,344,991	195,416	782	698.45	1,932.93	2,631.38	31,576.00
E	3,660,790	305,066	1,220	1,070.75	2,941.53	4,012.28	48,147.00

Source: Column 1. Estimated by function Y = 157,183.647 + 15.448 X where Y = kwh per year and X = annual output.
Column 2. Column 1 divided by 12.
Column 3. Assumed to be 4 kilowatts per 1,000 kwh consumed.
Column 4. Derived from Schedule A-7, general service of Southern California Edison Company, Los Angeles, effective January 15, 1958.
Column 5. Derived from Schedule A-7, general service of Southern California Edison Company, Los Angeles, effective January 15, 1958.
Column 6. Column 4 plus column 5.
Column 7. Column 6 times 12.

The negative intercept value would indicate that very small plants would be using a negative amount of water, a prediction which is unacceptable logically. Because of the small number of observations and the ensuing negative intercept, a linear function was forced through the origin and was used to estimate the water consumption (see Figure 7, Section B). The function was:

$$Y_8 = .362X_5.$$

To derive the costs of the water consumed, the water rates for the Los Angeles area were applied to the derived demand. Both the yearly and monthly requirements and costs are found in Table 21. The rates used call for a fixed service charge of $7.80 per month plus the following regressive quantitative charge for actual consumption:[1]

Rate Block (In units of 100 cubic feet)		Rate Per 100 Cubic Feet
First	33	18.4 cents
Next	300	16.2 cents
Next	3,000	12.6 cents
Next	17,000	10.4 cents
Excess of	20,333	8.0 cents

Natural Gas

Consumption of natural gas as fuel seemed to bear little relation to output, either for individual plants in the short-run, or over plants of varying size. Inasmuch as the major fuel item in a slaughter plant is for heating boilers, gas requirements were estimated from the amount of fuel needed to operate the boilers for an eight-hour interval daily.

---

[1] Rates were taken from Ordinance Approving New Water Rates Fixed by the Department of Water and Power, City of Los Angeles, effective on bills dated on and after November 1, 1959, Section 2.

TABLE 21

Annual Water Requirements and Costs for Synthesized Plants

Plant	Annual water requirements	Monthly water requirements	Monthly water costs	Annual water costs
	100 cubic feet		dollars	
Conventional:				
One-bed	11,585	965	134.30	1,612.00
Two-bed	23,901	1,992	271.51	3,258.00
Three-bed	34,209	2,851	371.94	4,463.28
On-the-rail:				
A	13,684	1,140	164.15	1,970.00
B	27,367	2,281	307.92	3,695.00
C	41,051	3,421	449.62	5,395.00
D	51,268	4,272	538.13	6,458.00
E	82,102	6,842	805.41	9,665.00

Source: Column 1. Annual output times (.362).
Column 2. Column 1 divided by 12.
Column 3. Derived by use of water rates from Ordinance Approving New Water Rates Fixed by the Department of Water and Power, City of Los Angeles, Effective on bills dated on and after November 1, 1959.
Column 4. Column 3 times 12.

Approximately 33,500 BTU's of heat -- the equivalent of 33.5 cubic feet of gas -- are required hourly per horsepower of boiler. Thus the hourly consumption of gas by a boiler operating at 100 percent efficiency would be the number of horsepower multiplied by 33.5 cubic feet per horsepower. Boilers, however, never operate at full efficiency because of heat loss and condition of boiler. Large boilers, however, usually operate more efficiently than smaller units. In this case, efficiency was increased linearly from 60 percent for a 10 horsepower boiler to 70 percent for a 60 horsepower boiler, with efficiency leveling off at 70 percent after 60 horsepower.[1] Hourly gas consumption per horsepower was estimated on the basis of 33.5 cubic feet divided by the efficiency percentage and then multiplied by 100. The resulting figures were multiplied by the respective horsepower and extended to a monthly level to which cost figures could be applied.

The cost rates used to determine fuel expenses were taken from schedule G-50 of the Southern California Gas Company, Los Angeles. The rates were as follows:

Commodity Charge	Effective Rate Per Meter Per Month
First 200 MCF, per MCF	56.3 cents
Next 800 MCF, per MCF	49.8 cents
Next 2,000 MCF, per MCF	48.2 cents
Next 3,000 MCF, per MCF	47.3 cents
Next 4,000 MCF, per MCF	46.1 cents
Next 10,000 MCF, per MCF	43.8 cents
Next 20,000 MCF, per MCF	42.7 cents

The average monthly cost (based on 21 working days per month) was multiplied by 12 to get the annual cost figure. The yearly gas requirements and costs and total utilities charges are found in Table 22.

---

[1] Calhoun, W. T., R. G. Bressler, Jr., C. L. Bedford, and H. H. White, Agricultural Processing Industries in the Columbia Basin Irrigation Project, report made by the Bureau of Agricultural Economics for the Committee on Problem 24, Columbia Joint Investigation, page A26.

TABLE 22

Annual Gas Requirements and Costs and Total Utility Costs for Synthesized Plants

Plant	Monthly gas requirement	Monthly cost of gas	Annual cost of gas	Total annual utilities cost
	cubic feet	dollars		
Conventional:				
One-bed	181,440	102.15	1,226	13,070
Two-bed	305,760	165.27	1,983	22,093
Three-bed	378,000	201.24	2,415	29,277
On-the-rail:				
A	222,600	123.85	1,486	14,818
B	342,720	183.67	2,204	24,624
C	443,520	233.87	2,806	34,275
D	524,160	274.03	3,288	41,322
E	806,400	414.59	4,975	62,787

Source: Column 1. See text for explanation of estimation procedure.
Column 2. Derived by application of Schedule G-50 of Southern California Gas Company, Los Angeles, to column 1.
Column 3. Column 2 times 12.
Column 4. Column 3 plus Table 21, column 4 plus Table 20, column 7.

Miscellaneous Supplies, Services

The cost functions which were derived by statistical techniques for these categories are given in Table 23 and are illustrated in Figure 8. However, a brief discussion of each of the cost items is needed in way of definition and explanation. The costs derived for each category are given in Table 24.

Repair and Maintenance

Repair and maintenance is composed of both variable and fixed cost components. A certain amount of maintenance cost is generally incurred simply to keep machinery in working order, even if the plant is not operating at all. Such a cost would be a fixed cost. Sammet comments:

> "Repair costs are properly attributable to both time and use. For example, the deterioration of hydraulic hose, electrical wiring and batteries, and all forms of corrosion are to a large extent a function of time. In fact, some such types of deterioration are accelerated by idleness. Other forms of wear increase with use."[1]

While such a division of repair and maintenance may be desirable, empirically such information may be impossible to obtain.

In the case of cattle slaughtering, the plant is generally operating at some level the year around, and the firm has little means of estimating how much of the expense results because of a time factor and how much results from the wear or use factor. For this reason, repair and maintenance costs were estimated jointly.[2]

Initially in trying to estimate a function for repair costs, total yearly repair and maintenance costs for building and machinery were regressed linearly against the total yearly cattle slaughter per plant (in

---

[1] Sammet, L. L., In-Plant Transportation Costs as Related to Materials Handling Methods -- Apple and Pear Packing, Berkeley: University of California, Giannini Foundation of Agricultural Economics, Mimeo. Report No. 142, January 1953, page 7. Also see Rogers and Bardwell, op. cit.

[2] For a further discussion of the joint nature of variable and fixed repair costs, see: Boles, op. cit., page 647.

TABLE 23

Estimated Functional Coefficients Between Various Costs and Yearly Output

Dependent variable	r	Constant term	Regression coefficient
		dollars	dollars per head
Killing costs	.505	7,010.745	.114 (.087)a/
Office costs	.883	3,561.957	.049 (.013)
Taxes and licenses	.987	2,084.840	.299 (.028)
Telephone	.9412	1,126.435	.269 (.048)
Delivery	.781	8,032.860	.212 (.085)
Repair and maintenance	b/	0	.339 b/
Feed and corral	b/	0	.100 b/
Buying costs	b/	0	.050 b/

a/ Standard errors of the coefficients are in parentheses.

b/ These items were not estimated.

Source: The coefficients were derived from data obtained in the study of eight California slaughter plants.

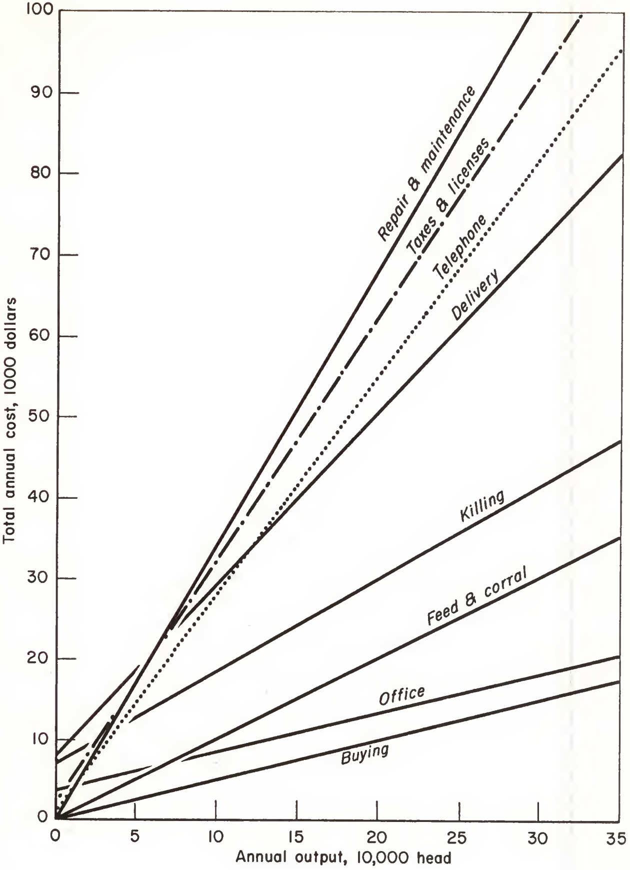


Figure 8. Annual Costs of Miscellaneous Categories as Functions of Yearly Output

TABLE 24

Miscellaneous Costs Associated with Various Rates of Output

Output per hour in number of head	Repair and maintenance costs	Killing costs	Office costs	Taxes and licenses	Telephone costs	Delivery costs	Feed and corral costs	Buying costs	Total other costs
	dollars								
10	6,407	9,165	4,488	7,736	6,210	12,040	1,890	945	48,881
12	7,688	9,596	4,673	8,866	7,227	12,841	2,268	1,134	54,293
15	9,568	10,228	4,945	10,524	8,719	14,016	2,822	1,411	62,233
17	10,849	10,659	5,130	11,654	9,736	14,818	3,200	1,600	67,646
20	12,814	11,320	5,414	13,387	11,295	16,046	3,780	1,890	75,946
25	15,975	12,383	5,871	16,175	13,803	18,023	4,712	2,356	89,298
30	19,221	13,474	6,340	19,038	16,379	20,053	5,670	2,835	103,010
35	22,382	14,537	6,797	21,826	18,887	22,030	6,602	3,301	116,362
40	25,628	15,629	7,266	24,689	21,463	24,060	7,560	3,780	130,075
45	28,789	16,692	7,723	27,477	23,971	26,037	8,492	4,246	143,427
50	32,035	17,784	8,192	30,340	26,547	28,067	9,450	4,725	157,140
60	38,443	19,938	9,118	35,991	31,631	32,074	11,340	5,670	184,205
75	48,010	23,156	10,502	44,430	39,223	38,057	14,162	7,081	224,621
120	76,885	32,866	14,675	69,898	62,136	56,114	22,680	11,340	346,594

Source: Column 1-8 were estimated by use of the functional relationships in Table 23.
Column 9. Sum of columns 1-8.

number of head). The resulting function, however, exhibited a negative intercept which would logically rule out extrapolation of the function to lower ranges of output. A mean cost of repair and maintenance per head of $0.339 was found in the plants surveyed and was used to estimate these costs. The mean value was not far different from the slope of .395 obtained in the linear function with the negative intercept.

Killing Supply Costs

Costs covered in this grouping include those items related principally to the kill floor itself, i.e., shrouds, shroud laundry, soap, shroud pins, neck skewers, ink, and towels. The function derived for estimating these costs has a coefficient of determination which is relatively low, a factor which may be caused by the lack of standard accounting procedures in defining killing costs.

Office Costs

Office costs include dues and subscriptions, miscellaneous supplies such as pencils, tags, postage, auditing credit expenses, and service to office machines.

Although some office costs remain fixed while the kill rate changes in the short-run, most of the items included in the office operation vary with the kill rate in both the short- and long-run (although such variability might exhibit a lagged effect until inventories of office supplies were depleted).

Taxes and Licenses

The taxes in this category are nonpersonal property taxes such as payroll taxes (unemployment and social security taxes). Also included in the classification are the licenses required to operate slaughter houses such as various city or community licenses (truck licenses are excluded, since assembly and delivery costs were not considered). These latter items are fixed in the short-run for a given plant while payroll taxes vary with labor requirements and hence the kill rate. Since the fixed portions of this particular cost item, however, are small relative to the variable part of the payroll taxes, it was felt that the effect on the nature of variable costs by including these fixed items with other taxes and licenses as a variable cost item would be negligible.

Telephone

Most of the selling in a cattle slaughtering plant is done via the telephone, and because of the widespread nature of many firms' marketing area, the telephone charge is an important expense item. A linear function relating costs per year to the kill per year was derived.

Delivery and Selling Costs

This cost category is assumed to include shipping supplies such as twine, butcher paper for lining the truck floors, tags, ink, and laundry of drivers' coats.

Feed and Corral Costs

Because of the great differences among the feeding programs of the various cattle slaughtering plants surveyed, a derived function based on accounting data would have little meaning for this cost item. Some plants operate their own feedlots and include the costs of feeding the cattle in feedlots with the cost of feeding the animals in the holding pens at the slaughter house. Therefore, based on the costs of plants which did not operate associated full feeding operations, a mean figure of $0.10 per head was allocated to the corral and feed costs for feeding all incoming cattle.1/

1/ This cost is solely that of feed. Labor and constructions costs have been considered previously.

Buying Costs

A lack of data on nonsalary buying costs prevented the estimation by regression techniques of a cost function for this item. The average of the few observations at hand was \$0.05 per head, a figure used to estimate the costs for the model plants. Of course, the buying costs in actuality may be dependent on the distances the buyer is required to go to supply the plant with the raw material. Trips into neighboring states to offset low supplies within the immediate vicinity because of seasonality factors may raise the per head charge above the assumed \$0.05.

Total Costs for Miscellaneous Supplies and Services

The preceding cost categories were summed for the various output levels, and the totals may be found in Table 24. The average costs exhibit economies as the scale of plant increases, a factor resulting from the intercepts of the various functions. The smallest plant (killing 10 head per hour or 18,900 head yearly) had an average cost of \$2.59 compared with \$1.84 for the larger on-the-rail plant killing 120 head per hour or 226,800 a year.

The individual cost functions for the separate categories when added together yield the following function:

$$Y_t = 21816.110 + 1.432X_5$$

where Y_t = total costs

X_5 = total annual slaughter in number of head.

TOTAL COSTS AND AVERAGE COST FUNCTIONS

Having derived the various cost components for eight model slaughter plants, the remaining task is to combine the various components into a meaningful whole. To do so, the costs shall be considered first in the short-run and then in the long-run.

Short-Run Cost Functions

For the short-run cost functions derived for the three conventional plants, costs of union labor and miscellaneous supplies and services were considered variable. Fixed costs, then, include depreciation, insurance, taxes, interest, salaried labor, and costs of utilities. The short-run constancy of the utility costs has been explained earlier. While the quantity of union labor in number of men is a variable input, such variation is made over time periods of more than one week since the union contract guarantees payment for a 40-hour week. Hence, the cost of adding an employee becomes fixed for periods up to one week no matter how output varies in that time.

Four output levels were considered for the one- and the two-bed plants and five levels for the three-bed plants. In each case, the least-cost point on the short-run function was where output was at designed capacity (see Table 25). The total cost functions for the three plants are step functions as opposed to smooth, continuous functions because the labor force remains constant for small shifts in output, although it varies over the entire range of output possible for a given plant. For example, 23 men are required to slaughter 30 head of cattle hourly in a two-bed plant. Although output might decrease to 27 head hourly, 23 men would still be used on the kill floor. For output greater than 30 head, labor requirements would move up to the next step. Therefore, within the output steps for a given plant, the only variable cost is the miscellaneous costs.

The estimated total and average cost points are given in Table 25 and the functions for the three plants are shown in Figures 9, 10, and 11.

Long-Run Costs

The long-run cost function becomes the envelope to those short-run cost functions. Since the short-run cost curves for on-the-rail plants were not estimated, the average cost points associated with capacity output for these plants were assumed to be minimum short-run average costs and to lie on the long-run cost curve for their respective technologies.

TABLE 25

Estimated Short-Run Costs for Three Synthesized Plants

Plant	Annual output	Annual fixed costs	Annual variable costs		Total	Variable cost per head	Total annual cost	Total cost per head
			Annual labor costs	Annual miscellaneous costs				
	number	dollars						
One-bed plants:								
Kill per hour								
10	18,900	101,166	94,676	48,881	143,557	7.60	244,723	12.95
12	22,680	101,166	107,504	54,293	161,797	7.13	262,963	11.59
15	28,224	101,166	127,857	62,233	190,090	6.74	291,256	10.32
17	32,004	101,166	134,497	67,646	202,143	6.32	303,309	9.48
Two-bed plants:								
Kill per hour								
20	37,800	184,859	153,514	75,946	229,460	6.07	414,319	10.96
25	47,124	184,859	191,781	89,298	281,079	5.96	465,938	9.89
30	56,700	184,859	238,224	103,010	341,234	6.02	526,093	9.28
35	66,024	184,859	258,557	116,362	374,919	5.68	559,778	8.48
Three-bed plants:								
Kill per hour								
30	56,700	260,804	250,209	103,010	353,219	6.23	614,023	10.83
35	66,024	260,804	277,355	116,362	393,717	5.96	654,521	9.91
40	75,600	260,804	329,530	130,075	459,605	6.08	720,409	9.53
45	84,924	260,804	349,258	143,427	492,685	5.80	753,489	8.87
50	94,500	260,804	376,511	157,140	533,651	5.65	794,455	8.41

Source: Column 1. Hourly kill multiplied by 7.5 hours per day times 252 days a year.
Column 2. Sum of building depreciation (Table 17); equipment depreciation (Table 16); tax costs (Table 18); insurance costs (Table 19); interest costs (Table 19); utilities costs (Table 22); and fixed labor costs (Table 10).
Column 3. Table 9.
Column 4. Table 24.
Column 5. Column 3 plus column 4.
Column 6. Column 5 divided by column 1.
Column 7. Column 2 plus column 5.
Column 8. Column 7 divided by column 1.

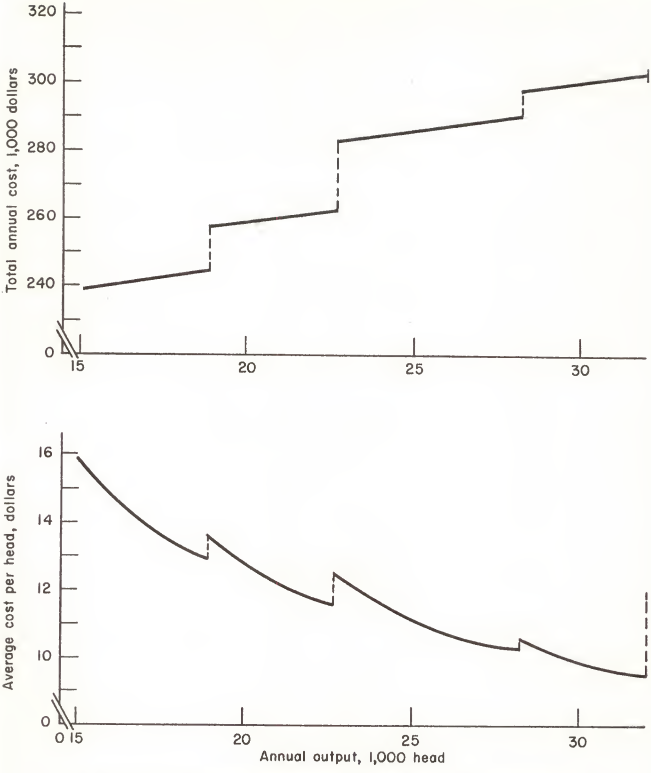


Figure 9. Short-Run Total and Average Cost Functions for Synthesized Conventional One-Bed Plant

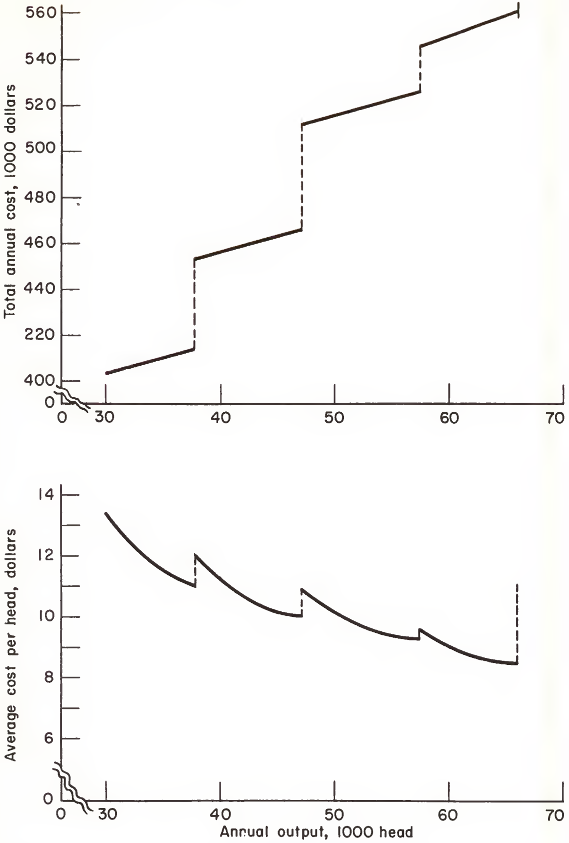


Figure 10. Short-Run Total and Average Cost Functions for Synthesized Two-Bed Plant

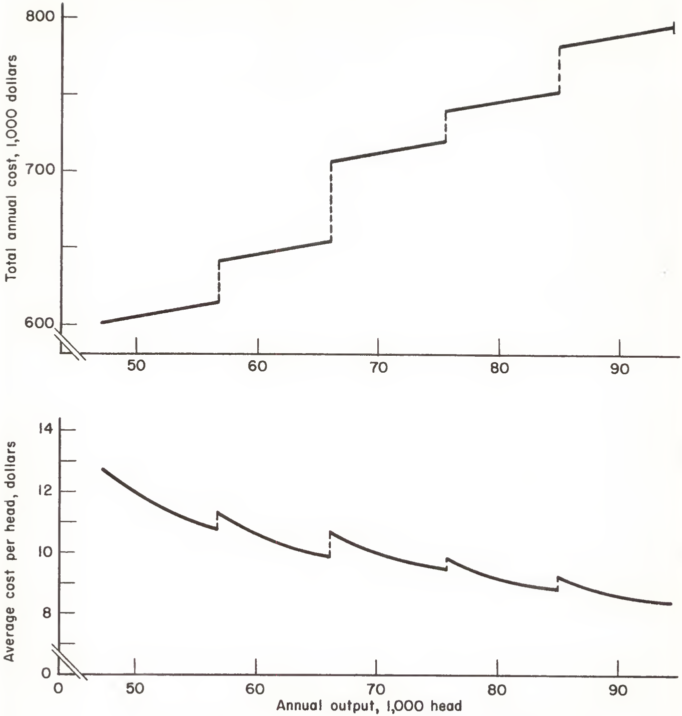


Figure 11. Short-Run Total and Average Cost Functions for Synthesized Conventional Three-Bed Plant

The total and average long-run cost points for the synthesized plants are given in Table 26 and the locus of the estimated average long-run cost points is shown in Figure 12.

The long-run average cost function for conventional plants will be discontinuous because of the indivisible nature of the killing floor over large ranges of outputs and the labor crew for smaller ranges. As can be seen from the inset in Figure 12, showing the section of the long-run cost points applicable to conventional plants, the discrete nature of the changes in size of the conventional plants plus the sudden sharp upturn in average costs at the point of designed capacity makes the long-run envelope pass through the least-cost points on the short-run curves. For outputs in the ranges between the designed capacities of the three conventional plants, however, the long-run average costs would lie below the short-run average cost curves for the three plants since variation of cooler space, office force and space -- inputs which are fixed in the short-run -- would make the long-run average costs for these inputs lower than the short-run average costs.

Because of the indivisible nature of the labor inputs of the killing crew, the total cost function for on-the-rail plants in the short-run also would be expected to be a step function. The same situation would exist in the long-run. However, expansion of the killing floor for on-the-rail plants is done principally by lengthening the existing line rather than adding multiple units. As a result, the severe discontinuities resulting from indivisibility of the killing floor would not be expected.

The average cost points for the synthesized plants evidence distinct economies of scale. Per head costs of slaughtering of $9.48 for the one-bed plant killing 17 head per hour (32,004 annually) decrease to $7.28 per head for the large on-the-rail plant slaughtering 120 head hourly (226,800 annually), a reduction of 23 percent ($2.20) in the average cost.

Several implications can be found from the envelope curve to the long-run average cost points in Figure 12. Perhaps the major item is the change in cost associated with changes in slaughtering techniques.

TABLE 26

Estimated Long-Run Costs of Synthesized Plants

Plant	Annual costs of								Total annual costs	Average cost
	Labor	Building depreciation	Equipment depreciation	Personal property taxes	Insurance	Interest	Other expenses	Utilities		
	dollars									
Conventional:										
One-bed	196,297	7,339	5,853	3,801	1,254	8,049	67,646	13,070	303,309	9.48
Two-bed	382,897	9,921	9,627	5,532	1,772	11,574	116,362	22,093	559,778	8.48
Three-bed	556,151	13,762	12,477	7,494	2,405	15,749	157,140	29,277	794,455	8.41
On-the-rail:										
A	245,275	7,638	8,428	4,736	1,515	9,671	75,946	14,818	368,027	9.74
B	473,893	11,837	12,687	7,183	2,282	14,809	130,075	24,624	677,390	8.96
C	666,018	17,164	19,998	10,930	3,458	22,355	184,205	34,275	958,403	8.45
D	745,469	20,151	23,034	12,715	4,022	26,062	224,621	41,322	1,097,396	7.75
E	1,113,661	30,598	32,510	18,958	6,004	38,985	346,594	62,787	1,650,097	7.28

Source:

Column	Source
Column 1.	Table 10.
Column 2.	Table 17.
Column 3.	Table 16.
Column 4.	Table 18.
Column 5.	Table 19.
Column 6.	Table 19.
Column 7.	Table 24.
Column 8.	Table 22.
Column 9.	Sum of columns 1-8.
Column 10.	Column 9 divided by yearly output.

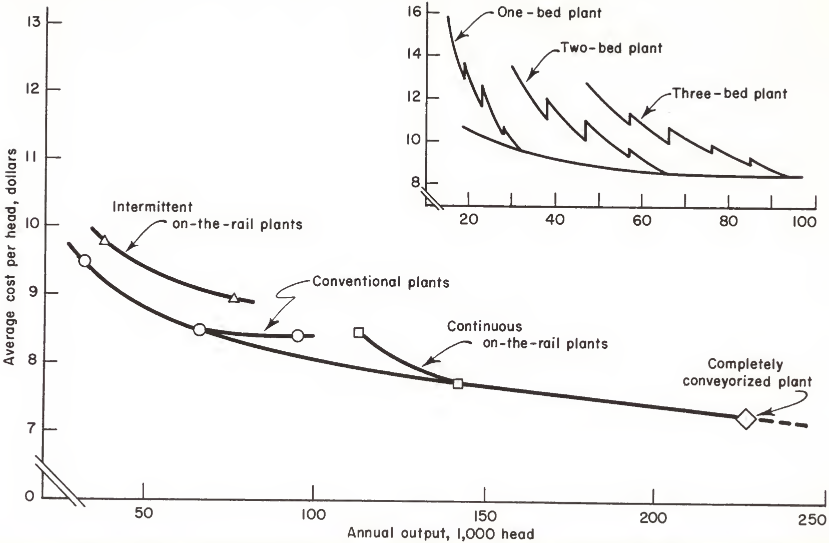


Figure 12. Envelope Curve to the Long-Run Average Cost Points for the Eight Synthesized Plants (inset in upper right shows envelope to the three short-run average cost functions for the conventional plants)

For smaller rates of slaughter (up to 50 head per hour), the conventional method of slaughtering offers lower costs per head than the modified rail system with drop rail sections and paunch trucks. Use of continuous on-the-rail systems involving moving-top viscera inspection tables, and head and tongue conveyors, pares the average cost of $7.75 for output of 75 head per hour. Finally, adoption of a completely conveyorized system for killing 120 head per hour results in an average cost figure of $7.28.

As an interjection, it should be noted that the previous discussion has included only cost differentials among the technologies. Factors such as worker satisfaction and product quality have not been considered. The on-the-rail system eliminates much of the stooping required in the flooring work in the conventional plants, since the carcass is "delivered" to the worker at a height which does not require much bending or stretching.

COSTS WITH SEASONAL VARIATION IN SLAUGHTER

The estimated short-run and long-run average costs carry the assumption that the plant will be operating at a uniform rate of output for an entire year. Often such may not be the case. Plants may alter their slaughtering rate for periods within a year because of seasonality of supply. In this section, the assumption of uniform rate of output during the entire year will be relaxed in an effort to analyze the effects of seasonality of supply of live animals on the costs of the firm.

Seasonal Variation in Slaughter

Slaughter of cattle and calves in California exhibits only a slight fluctuation from quarter to quarter. Quarterly indexes of seasonality were computed from 1953 through 1960 for the state as a whole with respect to slaughtering, marketing from feedlots, inshipments from other states, and marketing of dairy, cull beef, and grass-fed cattle. In addition, similar indexes were calculated for slaughtering in Los Angeles County and in the San Francisco Bay Area. The same procedure was followed in computing all the indexes. A moving index was constructed for the quarterly periods involved and the resulting percentages for each quarter were then averaged.[1]

The statewide indexes for slaughtering and the various sources of marketings are given in Table 27. During the 1953-60 period, the most animals generally were slaughtered in the third quarter (July-August-September), whereas the least number were killed in the first and second quarters.

The seasonal pattern for the state as a whole does not show any shifts of very great magnitude in one direction or the other. And, when the state is divided into northern and southern sectors, again there are few marked changes of slaughtering rates (see Table 28). In Los Angeles County, the index of quarterly slaughter was highest in the fourth quarter and lowest in the second period.[2] Although the over-all state pattern shows a slight decline in the fourth period, Los Angeles County slaughter registers an increase in October-November-December.

In Northern California, the Bay Area registers quarterly slaughtering percentages showing a rise from the first to second quarters while the fourth quarter declines to 102 percent from a third quarter level of 105 percent.

On the other hand, the various sources of animals for slaughter display decided fluctuations in the number of cattle and calves available for slaughter in particular quarters. The marketings of cattle from California feedlots for the period 1953-60 register a sharp difference between the second quarter and the remaining three periods. Inshipments of cattle and calves from other states also record seasonality with the first quarter having the highest number and the third quarter the lowest.[3]

---

[1] For a step-by-step description of the method of calculation used, see: Foote, R. J., and Karl A. Fox, Seasonal Variation: Methods of Measurement and Tests of Significance, Washington, D.C., U.S. Department of Agriculture, Agricultural Handbook No. 48, 1952, pp. 3-5.

[2] Percentages for the various divisions of the state are based on monthly slaughter figures published in California Crop and Livestock Reporting Service, California Monthly Slaughter Report, February 1950 through January 1961. Sacramento.

[3] Based on inshipment figures in California Crop and Livestock Reporting Service, California Annual Livestock Report, Summary for 1960, op. cit. page 10.

TABLE 27

Seasonal Patterns of Slaughtering and Marketing of Cattle and Calves in California

Item	Total slaughter	Source		
		Feedlots	Inshipments	Miscellaneous[a]
	thousand head			
Year:				
1953	2,859	1,034	739	1,086
1954	2,979	1,116	797	1,066
1955	3,174	1,340	667	1,167
1956	3,354	1,224	789	1,341
1957	3,161	1,229	658	1,274
1958	2,667	1,169	532	966
1959	2,665	1,441	523	701
1960	2,958	1,595	450	913
	index number			
Seasonal index:				
First quarter	98	111	113	73
Second quarter	98	80	103	118
Third quarter	104	104	88	111
Fourth quarter	100	105	96	98

[a] Includes culled animals from beef and dairy herds plus grass-fed cattle.

Source: Column 1. Based on cattle and calf slaughter figures reported in California Crop and Livestock Reporting Service, California Annual Livestock Report, Summary for 1960, op. cit., p. 12.

Column 2. Ibid., p. 13 and California Annual Livestock Report, Summary for 1956, p. 13.

Column 3. California Crop and Livestock Reporting Service, California Annual Livestock Report, Summary for 1960, op. cit., p. 10.

Column 4. Column 1 - columns 2 and 3.

Seasonal indexes: See text for description of derivation of index figures

TABLE 28

Seasonal Patterns of Slaughtering in Various Areas of California, 1950-60

Quarter	Commercial slaughter as a percent of mean quarterly kill in		
	Los Angeles County	San Francisco Bay Area[a]	State
First	100	95	98
Second	97	98	98
Third	101	105	104
Fourth	102	102	100

a/ Alameda, Contra Costa, Santa Clara, San Mateo and San Francisco.

Source: For description of derivation, see text.

The low level of inshipments in the third and fourth periods is generally offset by a high level of marketings from feedlots. Although in recent years the second quarter has seen an increase in inshipments which in a measure counteracts the low seasonal standard of marketings from feedlots it would seem that some other source must provide the stability found in the over-all slaughter. Such is the case. Cattle and calves from other sources are lowest in the first period, highest in the second quarter (low period for marketings from feedlots) and slack off in the third and fourth quarters when marketings from feedlots are increasing.1/

Many of the cattle and calves included in this latter category are culled dairy stock, although some grass-fed cattle and culled beef herd animals are included. Precise data are not available on the number of dairy animals slaughtered in California by quarters, but the number can be assumed to be fairly significant.

Plant Costs with Seasonal Variation

Of prime interest to the firm is the question: how much are costs changed on a per head basis because of seasonal fluctuations in the supply of live animals marketed? From the short-run average cost functions, one can study the effect of seasonal changes in slaughtering on the average costs.2/

Slaughtering for the state as a whole, it will be recalled, exhibited index figures of 98, 98, 104, and 100 percent for the first through fourth quarters, respectively. Hence, if all slaughtering firms were to face similar cutbacks in supplies of cattle, it would mean that the third quarter production would be accomplished at full capacity rate of output, while the first and second periods would be 94.2 percent of capacity and the

---

1/ Plants specializing in slaughter of only fat cattle, then would tend to experience greater seasonality in their supply than would plants slaughtering both fat cattle and dairy stock.

2/ Since short-run functions were not estimated for on-the-rail plants, analysis of seasonality effects on costs was limited to conventional bed-type plants.

fourth period 96.2 percent.[1] Thus, the conventional one-bed plants would have an hourly rate of 16 head in the first, second, and fourth quarters with full capacity output of 17 head per hour in the third quarter. The two-bed plant would slaughter 33 head per hour in the first and second periods, 35 head in the third quarter, and 34 head in the fourth quarter. Finally, the three-bed plant quarterly kill rates would be 47, 47, 50, and 48 head per hour for the first through fourth quarters, respectively.

To calculate the effect of the decreases in production for three quarters of the year, the following function was used:

(1) $TC = FC + \sum_i a_i v_i d_i$ where $i \leq 100$ percent and where $\Sigma d \leq 252$ (i.e., 5 days per week, 52 weeks per year minus 8 paid holidays = 252)

TC = total annual cost

FC = fixed cost

a_i = number of head slaughtered per day at capacity level i

v_i = average variable cost per head at capacity level i

d_i = number of days plant operated at capacity level i

(2) $ATC = \frac{Tc}{\sum_i a_i d_i}$

In applying the above equation to the cost and slaughtering data, the holiday structure called for two holidays in the first quarter, one in the second, two in the third, and three in the fourth period.[1] The number of holidays was subtracted from 65 working days to determine the number of days of actual operation for each quarter.

---

[1] Plants also face an alternative of working at full capacity the first and second periods and then working overtime or utilizing multiple shifts during the other periods. However, under the production conditions outlined for this study, particularly with respect to the cooler capacity, plants could not consider this alternative. Coolers were constructed to hold one day's kill (over an eight-hour shift) in the chill cooler and two days' kill (also based on an eight-hour shift) in the storage cooler. With the use of overtime work, therefore, either the coolers would have to be enlarged, or the policy of holding carcasses one day in the chill cooler and two days in the storage cooler would have to be changed. Such adjustments in the former case can readily be made by increasing cooler space and railing and then by adjusting the trolley and miscellaneous supply requirements.

The resulting estimations of total and average cost after consideration of the seasonality of slaughtering are given in Table 29.[2]

The net effect of the seasonality of slaughter is to reduce annual output for a given plant while increasing average costs, or to raise the long-run average cost curve slightly. In order to be able to slaughter at full capacity during the peak third quarter, the plant must have an excess capacity in coolers and killing floor during the remaining three quarters of the year. The charges for depreciation, interest, insurance, and personal property taxes, therefore, will be higher per head with irregular seasonal kill rates than if the reduced output were spread evenly over the entire year. For example, because of the seasonality, a one-bed plant must maintain cooler space capable of holding 381 head, (3 times its daily slaughter capacity) during the peak third quarter. During the other 3 periods, however, the coolers will hold only 360 head, leaving the coolers with an excess capacity of 21 head. On the other hand, a plant designed to handle the reduced output of 30,681 head evenly over the year would need a cooler capable of holding only 365 head.

Thus, the seasonality of supply of animals forces overcapacity in certain stages of the plant during portions of the year. The increase in average long-run cost is shown in Figure 13. The long-run envelope developed in Figure 12 is shown as the bottom line. Instead of operating at point A_3 with full capacity, the three-bed plant now operates at point B_3 with average costs of $8.70. Similarly the one- and two-bed plants now operate at points B_1 and B_2, respectively.

---

[1] Working Agreement and Wage Scale, op. cit., page 14.

[2] The estimated average variable costs which were not given in Table 7.1 are, by size of plant and hourly output: one-bed plant, 16 head, $6.60 per head; two-bed plant, 33 head, $5.94, 34 head, $5.80; three-bed plant, 47 head, $5.92 and 48 head, $5.82.

TABLE 29

Costs Associated with Reduced Output Resulting from Seasonality of Cattle Slaughter

Plant	Reduced output	Decrease from capacity	Total cost		Average cost	
			Reduced output	Capacity output	Reduced output	Capacity output
	number		dollars			
One-bed	30,681	1,323	301,420	303,309	9.82	9.48
Two-bed	63,685	2,339	556,643	559,778	8.74	8.48
Three-bed	90,649	3,851	788,835	794,455	8.70	8.41

Source: Column 1. Reduced output is calculated by the formula Output = $\Sigma a_i d_i$ where a_i and d_i are as defined in the text.
Column 2. Table 25, column 1 minus column 1 this table.
Column 3. See text for explanation of estimation procedure.
Column 4. Table 25, column 7.
Column 5. Column 3 divided by column 1.
Column 6. Table 25, column 8.

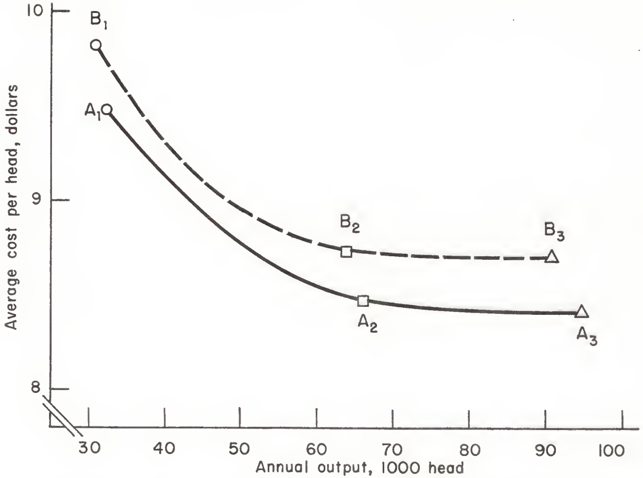


Figure 13. Changes in the Levels of Long-Run Average Costs Caused by Seasonality of Slaughter

SUMMARY AND CONCLUSIONS

The objectives of this study were to provide quantitative estimates of the short-run and long-run average cost functions for specialized beef slaughter plants in California. The procedure used to estimate these cost functions was one of synthesis; that is, estimating physical requirements and costs of the various inputs (e.g., labor) involved in the slaughtering operation and then combining the results as "building blocks" in formulating costs for model plants. Eight model plants were "constructed" which varied in designed capacity (measured in number of head killed per hour) and in technology. Five of these model plants relate to designed capacities of fifty head per hour or less and include two technologies; (1) conventional or bed-type slaughtering, and (2) intermittent on-the-rail dressing. The other three model plants relate to designed capacities of 60, 75, and 120-head per hour. The technology studied for these three plants was on-the-rail dressing with a continuous drive system for the first two and a completely conveyorized system for the largest plant.

Determination of the long-run average cost function was designed to answer two questions of importance to the industry in planning adjustments in plant size and technology to be employed: (1) For a given level of output, what technology of plant will provide the least-cost slaughtering and (2) how does the level of costs vary with the size of plant?

As to selection of technology, the conventional bed-type plants appear to offer a cost advantage over the intermittent on-the-rail system in the range of output between 17 and 50-head per hour. For the one-bed plant with designed capacity of 17 head per hour, costs per head were \$9.48; for the two-bed plant (35 head per hour) costs were \$8.48; and for the three-bed plant (50 head per hour) costs were \$8.41. These costs were somewhat lower in the comparable output range than those for the intermittent on-the-rail plants. For the plant with production capacity of 20 head per hour, costs were \$9.74 per head and \$8.94 per head for the plant with designed capacity of 40 head per hour.

In output ranges over 50 head per hour, only on-the-rail systems were analyzed and thus no direct statements are possible as to the optimum technology to employ. However, from the shape of the cost function associated with conventional plants (see Figure 12) it appears reasonable to infer that the on-the-rail system would provide lower cost slaughtering operations than would the replication of multiple-bed plants even though there might be some cost savings involved if these beds were included in one plant.

As to the variation in costs associated with size of plant, costs, in general, tend to decrease over the range in output studied. However, for a particular technology, that of the conventional bed-type plant, the average cost per head decreases only slightly between the two- and three-bed plants. Also, the low output on-the-rail plant exhibits costs slightly higher than the three-bed plant. These costs are as follows:

Output in head per hour	Average total cost per head	Type of plant
	dollars	
17	9.48	one-bed conventional
35	8.48	two-bed conventional
50	8.41	three-bed conventional
60	8.45	on-the-rail continuous
75	7.75	on-the-rail continuous
120	7.28	on-the-rail completely conveyorized

The cost for the completely conveyorized on-the-rail plant is $2.20 per head lower than for the one-bed plant when each is operated at capacity, and equal to 77 percent of the one-bed average costs.

Two additional questions were posed in the objectives of this study; namely: (1) How will average costs per head slaughtered vary if the plant is operated at, say, 70 percent of capacity as compared with 100 percent of capacity and (2) how do costs of slaughtering vary as the supply of animals changes because of seasonal factors?

Short-run cost curves were estimated only for the three conventional bed-type slaughter plants (see Table 25). From these data we can provide an answer to the first question posed above. For illustration, if the three-bed plant is operated uniformly throughout the year at only 70 percent of capacity, the average cost per head slaughtered equals $9.91, or

118 percent of the cost at capacity output ($8.41). For other levels of capacity, the costs are as follows: 60 percent of capacity, $10.83; 80 percent, $9.53; and 90 percent, $8.87. In deciding on the size of plant to construct, it is important to consider whether supply considerations warrant the operation of the plant at full capacity. For example, if there is assurance of a slaughter rate of 35 head per hour, costs would be lower for the operation of a two-bed plant at capacity rather than the operation of the three-bed plant at only 70 percent of capacity.

These short-run cost functions also provide information as to the effect of seasonal variation in slaughter on costs. Total slaughter of cattle in California for the period 1953-60 showed a quarterly seasonal index of supply of 98, 98, 104, and 100 percent for the first to fourth quarters, respectively. If the plant is operated at designed capacity during the third quarter, it will operate at less than capacity during the other three quarters, resulting in higher cost slaughtering. As a result of these seasonal cutbacks, average per-head costs are increased by over 3 percent for the conventional plants, equalling $9.82, $8.74, and $8.70 for the one-, two-, and three-bed plants respectively.

This study was limited to cattle-slaughtering operations only and did not consider associated operations such as rendering, curing hides, sausage-making, or breaking carcasses into various cuts of meats. Such integration a priori might be expected to reduce the average costs of the slaughtering operation as a result of joint use of facilities such as buildings, utility fixtures, and management which in this analysis are used only for slaughtering. Total costs, however, would be expected to rise as additional labor, equipment and other inputs would be required in the associated operations.

A separate analysis would be required to determine whether these associated operations should be integrated with slaughtering operations. Considerations such as availability of local rendering plants and the nature of the market for processed by-products for example, would enter the decision as to whether it would be more profitable for the slaughtering firm to sell nonedible by-products or to process them.

APPENDIX TABLES

TABLE A-1

Synthesized Crew Sizes for Two-Bed Plants with Varying Rates of Output

Operation	Output per hour, in number of head							
	20		25		30		35	
	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.
Kill, remove head, and wash head:								
Knock, shackle, stick	1.0	40.0	1.0	40.0	1	40.0	--	--
Knock, shackle	--[a]	--	--	--	--	--	1	60.0
Stick, head, face	--	--	--	--	--	--	1	23.1
Face, head, wash head	1.0[b]	28.6	1.0[b]	28.6	1	28.6	--	--
Wash head	--	--	--	--	1[c]	60.0[d]	1[c]	60.0[d]
Remove head, eviscerate, split, and scribe:								
Side, leg	2.5	21.4	3.0	25.7	4	34.3	5	48.0
Rump, back	1.5	25.1	2.0	26.4	3	31.1	4	37.0
Gut	1.0	35.0	1.0	35.0	1	35.0	1	35.0
Hide drop	[c]	--	1.0[f]	40.0	1	40.0	1	40.0
Split	.5	23.1	.5	23.1	1	46.2	1	46.2
Scribe	.5	25.0	.5	25.0	1	50.0	1	50.0
Carcass finishing:								
Wash, high and low	1.0	25.0	1.0	25.0	--	--	--	--
Wash high	--	--	--	--	1	50.0	1	50.0
Wash low	--	--	--	--	1	50.0	1	50.0
Scale and shroud	1.0	20.7	--	--	--	--	--	--
Scale	--	--	1.0	75.0	1	75.0	1	75.0
Shroud, high and low	--	--	1.0	35.0	1	35.0	1	35.0
Other:								
Head work-up[d]	1.0	--	1.0	--	1	--	1	--
Truck guts	[g]	--	[g]	--	1	50.0[h]	1	50.0[h]
Tripe work-up[d]	1.0	--	2.0	--	2	--	2	--
Offal work-up[d]	[i]	--	1.0	--	1	--	1	--
TOTAL	12.0		17.0		23		25	

a/ Dashes indicate the position is not utilized as specified for the particular output level in question.

b/ Facer also helps stick the live animals.

c/ Head washer helps with the facing and heading.

d/ Based on crew specifications provided by the Allbright-Nell Co., Chicago.

e/ Knocker also drops the hide.

f/ Hide dropper helps in rumping and backing operations.

g/ Gutter also trucks the guts.

h/ Based on Hammons and Miller, op. cit., p. 47.

i/ Head work-up man also works up offal.

Source: Crew requirements were synthesized from the production data in Table 3.

TABLE A-2

Synthesized Crew Sizes for Three-Bed Plants with Varying Rates of Output

Operation	Output per hour, in number of head									
	30		35		40		45		50	
	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.	No. of workers	Capacity in head per hr.
Kill, remove head, and wash head:										
Knock, shackle, stick	1	40.0	1.0	40.0	--[a]		--		--	
Knock, shackle	--		--		1	60.0	1	60.0	1	60.0
Stick, face, head	--		--		2	46.2	2	46.2	3	69.3
Face, head	1	28.6	1.5	42.9	--		--		--	
Wash head	1[b]	60.0	1.0[b]	60.0	1	60.0	1	60.0	1	60.0
Remove hide, eviscerate, split and scribe:										
Side, leg	4	34.3	5.0	48.0	5	48.0	5	48.0	6	51.8
Rump, back	3	31.1	4.0	42.9	4	42.9	5	45.0	6	52.8
Gut	1	35.0	1.0	35.0	2	70.0	2	70.0	2	70.0
Drop hide	1	40.0	1.0	40.0	2[c]	80.0	2[c]	80.0	2	80.0
Split	1	46.2	1.0	46.2	1	46.2	1	46.2	2	92.4
Scribe	1	50.0	1.0	50.0	1	50.0	1	50.0	1	50.0
Carcass finishing:										
Wash high	1	50.0	1.0	50.0	1	50.0	1	50.0	1	50.0
Wash low	1	50.0	1.0	50.0	1	50.0	1	50.0	1	50.0
Scale	1	75.0	1.0	75.0	1	75.0	1	75.0	1	75.0
Shroud high and low	1	35.0	--		--		--			
Shroud high	--		1.0	50.0	1	50.0	1	50.0	1	50.0
Shroud low	--		1.0	50.0	1	50.0	1	50.0	1	50.0
Other:										
Head work-up[d]	1		1.5		2		2		2	
Truck guts	1[e]	50.0	1.0	50.0	2[f]		2[f]		2[f]	
Tripe work-up	2		2.0		2		2		2	
Offal work-up[d]	1		1.0		1		2		2	
TOTAL	23		27.0		31		33		37	

[a] Dashes indicate the position is not utilized as specified for the particular output level in question.

[b] Head washer also helps with facing and heading.

[c] Hide dropper helps in rumping and backing operation.

[d] Based on crew specification provided by the Allbright-Nell Co., Chicago.

[e] Guts trucker helps with offal work-up.

[f] Although the production capacity of one worker is shown as 50 head per hour, it was felt that such a rate based on a one-bed plant could not be maintained in the larger area of the three-bed plant. Therefore a second worker was added at the 40 head per hour rate.

Source: Crew requirements were synthesized from the production data in Table 3.

TABLE A-3

Synthesized Crew Sizes for Intermittent On-the-Rail Systems with Given Rates of Output

Operation	Number of men required to kill	
	20 head	40 head
	per hour	
Kill, remove head, and wash head:		
Drive, pen, knock	.67	1.00
Shackle, hoist, stick, scalp, head	.67	2.00
Tag, cut off head, dehorn, wash head	.67	1.00
Remove hide, eviscerate, split, and scribe:		
Skin leg, punch gam, saw off, skin gam and punch, rip and point tail	.50	1.00
Transfer from bleeding to skinning rail, remove udder or pizzle, mark aitch bone	.50	1.00
Skin leg and saw off, split aitch bone	.50	.50
Drop bung	.50	.50
Turn round and flank both sides to naval	.50	1.00
Skin fell, rump and pull tail	.50	1.00
Skin and remove front feet, raise and tie weasand, clean neck both sides	.50	1.00
Mark and saw brisket, rim over right and left brisket	.50	1.00
Turn shank, clear rosette, neck and drop hide	1.00	2.00
Skin sides, high and low back	1.00	3.00
Transfer to flat rail	.50	.25
Eviscerate (paunch truck)	1.00	1.00
Split	.50	.75
Trim bruises	.50	1.00
Remove passed viscera	1.00	1.00
Scribe and trim neck	.50	1.00
Carcass finishing:		
Scale	.50	1.00
High and low wash	1.00	2.00
High and low shroud	.50	2.00
Other:		
Utility and relief	1.00	1.00
Tripe work-up	1.00	2.00
Offal work-up	.50	1.00
Head work-up	.50	2.00
TOTAL	17.00	32.00

Source: Taken from specifications supplied by the Allbright-Nell Co., Chicago.

TABLE A-4

Synthesized Crew Sizes for Continuous On-the-Rail
Systems with Given Rates of Output

Operation	Number of men required to kill 60 head per hour	75 head per hour	120 head per hour
Kill, remove head, and wash head:			
Drive, pen, knock cattle	1.00	2.00	3.00
Shackle, hoist, stick, scalp, head	3.00	3.00	5.00
Tag, cut off, dehorn, wash head	1.00	2.00	3.00
Remove hide, eviscerate, split, and scribe:			
Skin legs, punch gams, rip and point tail	2.00	2.00	4.00
Transfer from bleeding conveyor to skinning conveyor	1.00	1.00	2.00
Remove shackle, skin legs, cut off	1.00	2.00	3.00
Remove udder or pizzle, mark aitch bone	.50	1.00	1.00
Drop bung	1.00	1.00	2.00
Split aitch bone	.50	1.00	1.00
Turn round and flank both sides to naval	2.00	2.00	3.00
Skin fell, rump both sides, pull tail	2.00	2.00	3.00
Skin, remove front feet, raise and tie weasand	2.00	1.50	3.00
Open and turn shanks, clear necks	1.00	1.50	2.00
Mark and saw brisket	.50	1.00	1.00
Rim over brisket both sides	.50	1.00	2.00
Skin rosettes and neck	2.00	2.00	3.00
Operate hide puller	1.00	1.00	1.00
Low back	1.00	1.00	2.00
High back	1.00	1.00	2.00
Transfer from skinning to eviscerating and inspection conveyor (automatic)	--	--	--
Eviscerate	2.00	2.00	3.00
Split carcass	1.00	1.00	2.00
Scribe and trim bruises	1.00	1.00	2.00
Carcass finishing:			
Scale and tag	2.00	2.00	2.00
High and low wash	2.00	3.00	4.00
High and low shroud	2.00	2.00	4.00
Other:			
Utility and relief	2.00	2.00	4.00
Remove passed viscera	2.00	2.00	2.00
Head work-up	2.00	3.00	5.00
Tripe work-up	3.00	4.00	7.00
Offal work-up	1.00	2.00	2.00
TOTAL	44.00	53.00	83.00

Source: Taken from specifications supplied by the Allbright-Nell Co., Chicago.

TABLE A-5

Wage Rates for Hourly Slaughter Plant Workers in the Los Angeles Area

Operation	Wage rate effective October 1960-61 hourly	Wage rate effective October 1960-61 yearly	Vacation pay	Sick leave	Fringe benefits	Total excess	Total year rate
	dollars						
Conventional operations:							
Knocker	2.62	5,449.60	108.80	108.80	454.80	672.40	6,122
Shackler	2.62	5,449.60	108.80	108.80	454.80	672.40	6,122
Sticker	2.86	5,948.80	118.40	118.40	454.80	691.60	6,640
Header	2.82	5,865.60	116.80	116.80	454.80	688.40	6,554
Facer	2.70	5,616.00	112.00	112.00	454.80	678.80	6,295
Floorsman	3.30	6,864.00	136.00	136.00	454.80	726.80	7,591
Legger	2.70	5,616.00	112.00	112.00	454.80	678.80	6,295
Rumper	3.06	6,364.80	126.40	126.40	454.80	707.60	7,072
Backer	3.10	6,448.00	128.00	128.00	454.80	710.80	7,159
Gutter	2.74	5,699.20	113.60	113.60	454.80	682.00	6,381
Hide dropper	2.86	5,948.80	118.40	118.40	454.80	691.60	6,640
Splitter	3.30	6,864.00	136.00	136.00	454.80	726.80	7,591
Scriber	2.78	5,782.40	115.20	115.20	454.80	685.20	6,468
High washer	2.58	5,366.40	107.20	107.20	454.80	669.20	6,036
Low washer	2.58	5,366.40	107.20	107.20	454.80	669.20	6,036
Scaler	2.62	5,449.60	108.80	108.80	454.80	672.40	6,122
High shrouder	2.66	5,532.80	110.40	110.40	454.80	675.60	6,208
Low shrouder	2.66	5,532.80	110.40	110.40	454.80	675.60	6,208
Guts trucker	2.50	5,200.00	104.00	104.00	454.80	662.80	5,863
Tripe work-up man	2.70	5,616.00	112.00	112.00	454.80	678.80	6,295
Offal work-up men	2.70	5,616.00	112.00	112.00	454.80	678.80	6,295
Head washer	2.42	5,033.60	100.80	100.80	454.80	656.40	5,690
Foreman	3.66	7,612.80	150.40	150.40	454.80	755.60	8,368
Common labor	2.42	5,033.60	100.80	100.80	454.80	656.40	5,690
Head work-up	2.70	5,616.00	112.00	112.00	454.80	678.80	6,295
Maintenance:	3.18	6,614.40	131.20	131.20	434.00	696.40	7,311
Gang leader	3.30	6,864.00	136.00	136.00	434.00	706.00	7,570
Foreman	3.54	7,363.20	145.60	145.60	434.00	725.20	8,088
Cooler men:	2.70	5,616.00	112.00	112.00	434.00	658.00	6,274
Dock workers:							
Dock foreman	3.22	6,697.60	132.80	132.80	434.00	699.60	7,397
Scaling order clerk	2.86	5,948.80	118.40	118.40	434.00	670.80	6,620
Putting up orders	2.66	5,532.80	110.40	110.40	434.00	654.80	6,188
Checkers on dock	2.70	5,616.00	112.00	112.00	434.00	658.00	6,274
Dock foreman (less than 5 trucks)	3.10	6,448.00	128.00	128.00	434.00	690.00	7,138
Yardman	2.50	5,200.00	104.00	104.00	434.00	642.00	5,842
Clean-up man	2.42	5,033.60	100.80	100.80	434.00	635.60	5,669
On-the-rail operations:							
Rumping	3.06	a/	a/	a/	a/	a/	7,072
Backer	3.10						7,159
Hide dropper	2.86						6,640
Clear out around cod, udder and inside flank	2.74						6,381
Finish skinning flank	3.30						7,591
Rim over	3.30						7,591
Skin brisket, cut pattern	3.30						7,591
Skin neck	2.82						6,554
Cut fell, skin inside and outside hind shank	2.74						6,381
Clear out neck and foreshank	2.74						6,381
Hide puller	2.82						6,554
Splitter	3.30						7,591

a/ Derivation of the total yearly rate for on-the-rail workers is the same as for the conventional plants; therefore, the figures in columns 2 through 6 are not repeated.

Source: Column 1. Working Agreement and Wage Scale, op. cit.
Column 2. Yearly total is based on 2,080 hours or 260 days of 8 hours each, including 8 holidays.
Column 3. Based on one week's vacation, paid at the regular wage rate plus 10 cents per hour premium for the extra man.
Column 4. Based on one week's sick leave, paid at the regular wage rate plus 10 cents per hour premium for the extra man.
Column 5. Includes health and welfare ($174.00); pension ($208.00); clothes change allowance ($52.00); and tools ($20.80).
Column 6. Columns 3 plus 4 plus 5.
Column 7. Columns 2 plus 6 (rounded to the nearest dollar).

TABLE A-6

Kill Crew Annual Labor Cost in Two-Bed Plants for Various Rates of Output

Operation	Output per hour, in number of head							
	20		25		30		35	
	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker
		dollars		dollars		dollars		dollars
Kill, remove head and wash head:								
Knock, shackle, stick	1.0	6,640	1.0	6,640	1.0	6,640	--[a]	
Knock, shackle	--		--		--		1.0	6,122
Stick, head, face	--		--		--		1.0	6,554
Face, head, wash head	1.0	6,640	1.0	6,640	1.0	6,554	--	
Wash head	--		--		1.0	6,295	1.0	6,295
Remove hide, eviscerate, split, and scribe:								
Side, leg	2.5	7,591	3.0	7,591[b]	4.0	7,591[b]	5.0	7,591[b]
Rump, back	1.5	8,368[c]	2.0	8,368[c]	3.0	8,368[d]	4.0	8,368[e]
Gut	1.0	6,381	1.0	6,381	1.0	6,381	1.0	6,381
Drop hide	--		1.0	7,072	1.0	6,640	1.0	6,640
Split	.5	7,591	.5	7,591	1.0	7,591	1.0	7,591
Scribe	.5	[f]	.5	[f]	1.0	6,468	1.0	6,468
Carcass finishing:								
Wash, high and low	1.0	6,036	1.0	6,036	--		--	
Wash high [g]	(1.0)	(6,036)	(1.0)	(6,036)	1.0	6,036	1.0	6,036
Wash low [g]	(1.0)	(6,036)	(1.0)	(6,036)	1.0	6,036	1.0	6,036
Scale and shroud	1.0	6,208	--		--		--	
Scale	--		1.0	6,122	1.0	6,122	1.0	6,122
Shroud, high and low	--		1.0	6,208	1.0	6,208	1.0	6,208
Others:								
Head work-up	1.0	6,295	1.0	6,295	1.0	6,295	1.0	6,295
Truck guts	--		--		1.0	5,863	1.0	5,863
Tripe work-up	1.0	6,295	2.0	6,295	2.0	6,295	2.0	6,295
Offal work-up	--		1.0	6,295	1.0	6,295	1.0	6,295
TOTAL	12.0 (13.0)	82,708 (88,744)	17.0 (18.0)	114,787 (120,823)	23.0	153,681	25.0	167,826

[a] Dashes indicate the position is not utilized as specified for the particular output level in question.

[b] One worker is paid legger's rate of $6,295.

[c] One worker is paid rumper's rate of $7,072.

[d] One worker is paid rumper's rate of $7,072 and one worker is paid backer's rate of $7,159.

[e] Two workers are paid rumper's rate of $7,072 and one worker is paid backer's rate of $7,159.

[f] Laborers dividing their time between two or more different jobs are paid the full amount of the higher-paying classification.

[g] Figures in parentheses represent short-run costs for plant killing 35 head per hour.

Source: Crew requirements are taken from Table A-1, and wage rates are taken from Table A-5.

TABLE A-7

Kill Crew Annual Labor Cost in Three-Bed Plant for Various Rates of Output

Operation	Output per hour, in number of head									
	30		35		40		45		50	
	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker	No. of workers	Annual cost per worker
		dollars		dollars		dollars		dollars		dollars
Kill, remove head, and wash head:										
Knock, shackle, stick	1	6,640	1.0	6,640	--[a]		--			
Knock, shackle,	--		--		1	6,122	1	6,122	1	6,122
Stick, face, head	--		--		2	6,640	2	6,640	3	6,640[b]
Face, head	1	6,554	1.5	6,554	--		--			
Wash head	1	6,295	1.0	6,295	1	5,690	1	5,690	1	5,690
Remove hide, eviscerate, split, and scribe:										
Side, leg	4	7,591[c]	5.0	7,591[c]	5	7,591[c]	5	7,591[c]	6	7,591[d]
Rump, back	3	8,368[e]	4.0	8,368[f]	4	8,368[f]	5	8,368[g]	6	8,368[h]
Gut	1	6,381	1.0	6,381	2	6,381	2	6,381	2	6,381
Drop hide	1	6,640	1.0	6,640	2	6,640[i]	2	6,640[i]	2	6,640[i]
Split	1	7,591	1.0	7,591	1	7,591	1	7,591	2	7,591
Scribe	1	6,468	1.0	6,468	1	6,468	1	6,468	1	6,468
Carcass finishing:										
Wash high [j]	1	6,036	1.0	6,036	1	6,036	1	6,036	1	6,036
Wash low [j]	1	6,036	1.0	6,036	1	6,036	1	6,036	1	6,036
Scale	1	6,122	1.0	6,122	1	6,122	1	6,122	1	6,122
Shroud high and low [j]	1	6,208	--		--		--			
Shroud high [j]	(1)	(6,208)	1.0	6,208	1	6,208	1	6,208	1	6,208
Shroud low [j]	(1)	(6,208)	1.0	6,208	1	6,208	1	6,208	1	6,208
Other:										
Head work-up	1	6,295	1.5	6,295	2	6,295	2	6,295	2	6,295
Truck guts	1	5,863	1.0	5,863	2	5,863	2	5,863	2	5,863
Tripe work-up	2	6,295	2.0	6,295	2	6,295	2	6,295	2	6,295
Offal work-up	1	6,295	1.0	6,295	1	6,295	2	6,295	2	6,295
TOTAL	23 (24)	153,681 (159,889)	27.0	180,847	31	205,766	33	219,220	37	246,473

[a] Dashes indicate position is not utilized as specified.

[b] One worker is paid facer's rate of $6,295.

[c] One worker is paid legger's rate of $6,295.

[d] Two workers are paid legger's rate of $6,295.

[e] One worker is paid rumper's rate of $7,072, and one worker is paid backer's rate of $7,159.

[f] Two workers are paid rumper's rate of $7,072, and one worker is paid backer's rate of $7,159.

[g] Two workers are paid rumper's rate of $7,072,and two workers are paid backer's rate of $7,159.

[h] Three workers are paid rumper's rate of $7,072, and two workers are paid backer's rate of $7,159.

[i] One worker is paid rumper's rate of $7,072.

[j] Figures in parentheses represent short-run costs for plant killing 50 head per hour.

Source: Crew requirements are taken from Table A-2,and wage rates are taken from Table A-5.

TABLE A-8

Kill Crew Annual Labor Cost in Intermittent On-The-Rail Systems for Given Rates of Output

Operation	Output per hour, in number of head			
	20		40	
	Number of workers	Annual cost per worker dollars	Number of workers	Annual cost per worker dollars
Kill, remove head, and wash head:				
Drive, pen, knock	.67	a/	1.00	6,122
Shackle, hoist, stick, scalp, head	.67	6,640	2.00	6,640
Tag, cut off head, dehorn, wash head	.67	a/	1.00	5,690
Remove hide, eviscerate, split, and scribe:				
Skin leg, punch gam, saw off, skin gam and punch, rip and point tail	.50	6,295	1.00	6,295
Transfer from bleeding to skinning rail, remove udder or pizzle, mark aitch bone	.50	a/	1.00	5,690
Skin leg and saw off, split aitch bone	.50	a/	.50	
Drop bung	.50	7,072	.50	7,072
Turn round and flank both sides to naval	.50	7,591	1.00	7,591
Skin fell, rump and pull tail	.50	a/	1.00	7,072
Skin and remove front feet, raise and tie weasand, clean neck both sides	.50	a/	1.00	6,295
Mark and saw brisket, rim over right and left brisket	.50	7,591	1.00	7,591
Turn shank, clear rosette, neck and drop hide	1.00	6,554	2.00	6,554
Skin sides, high and low back	1.00	8,368	3.00	8,368 b/
Transfer to flat rail	.50		.25	
Eviscerate (Paunch truck 20-40)	1.00	6,381	1.00	6,381
Split	.50	7,591	.75	7,591
Trim bruises	.50	a/	1.00	6,468
Remove passed viscera	1.00	5,863	1.00	5,863
Scribe and trim neck	.50	6,468	1.00	6,468
Carcass finishing:				
Scale	.50	a/	1.00	6,122
High and low wash	1.00	6,036	2.00	6,036
High and low shroud	.50	6,208	2.00	6,208
Others:				
Utility and relief	1.00	6,554	1.00	6,554
Tripe work-up	1.00	6,295	2.00	6,295
Offal work-up	.50	6,295	1.00	6,295
Head work-up	.50		2.00	6,295
TOTAL	17.00	114,442	32.00	210,766

a/ Laborers dividing their time between two or more different jobs are paid the full amount of the higher-paying classification.

b/ Two workers are paid at floorman's rate of $7,591.

Source: Crew requirements are taken from Table A-3, and wage rates are taken from Table A-5.

TABLE A-9

Kill Crew Annual Labor Cost in Continuous On-the-Rail Systems for Given Rates of Output

Operation	Output per hour, in number of head					
	60		75		120	
	Number of workers	Annual cost per worker	Number of workers	Annual cost per worker	Number of workers	Annual cost per worker
		dollars		dollars		dollars
Kill, remove head, and wash head:						
Drive, pen cattle, knock	1.00	6,122	2.00	6,122	3.00	6,122
Shackle, hoist, stick, scalp, head	3.00	6,640	3.00	6,640	5.00	6,640
Tag, cut off, dehorn and wash head	1.00	5,690	2.00	5,690	3.00	5,690
Remove hide, eviscerate, split, and scribe:						
Skin legs, punch gams, rip and point tail	2.00	6,295	2.00	6,295	4.00	6,295
Transfer from bleeding conveyor to skinning conveyor	1.00	5,690	1.00	5,690	2.00	5,690
Remove shackle, skin legs, cut off	1.00	6,295	2.00	6,295	3.00	6,295
Remove udder or pizzle, mark aitch bone	.50		1.00	6,381	1.00	6,381
Drop bung	1.00	7,072 a/	1.00	7,072	2.00	7,072
Split aitch bone	.50	6,468	1.00	6,468	1.00	6,468
Turn round and flank both sides to naval	2.00	7,591	2.00	7,591	3.00	7,591
Skin fell, rump both sides, pull tail	2.00	7,072	2.00	7,072	3.00	7,072
Skin, remove front feet, raise and tie weasand	2.00	6,295	1.50	6,295	3.00	6,295
Open and turn shanks, clear necks	1.00	6,381	1.50	6,381 b/	2.00	6,381
Mark and saw brisket	.50	a/	1.00	6,468	1.00	6,468
Rim over brisket both sides	.50	7,591	1.00	7,591	2.00	7,591
Skin rosettes and neck	2.00	6,554	2.00	6,554	3.00	6,554
Low back	1.00	8,368	1.00	8,368	2.00	8,368 c/
High back	1.00	7,159	1.00	7,159	2.00	7,159
Eviscerate	2.00	6,381	2.00	6,381	3.00	6,381
Saw rump and loin, backs and chuck	1.00	7,591	1.00	7,591	2.00	7,591
Scribe and trim bruises	1.00	6,468	1.00	6,468	2.00	6,468
Carcass finishing:						
Scale and tag	2.00	6,122	2.00	6,122	2.00	6,122
High and low wash	2.00	6,036	3.00	6,036	4.00	6,036
High and low shroud	2.00	6,208	2.00	6,208	4.00	6,208
Other:						
Utility and relief	2.00	6,554	2.00	6,554	4.00	6,554
Remove passed viscera	2.00	5,863	2.00	5,863	2.00	5,863
Operate hide puller	1.00	6,554	1.00	6,554	1.00	6,554
Head work-up	2.00	6,295	3.00	6,295	5.00	6,295
Tripe work-up	3.00	6,295	4.00	6,295	7.00	6,295
Offal work-up	1.00	6,295	2.00	6,295	2.00	6,295
TOTAL	44.00	287,081	53.00	343,044	83.00	538,974

a/ Laborers dividing their time between two or more different jobs are paid the full amount of the higher-paying classification.

b/ Two workers are paid $6,381 and one worker is paid $6,295.

c/ One worker is paid $7,159.

Source: Crew requirements are taken from Table A-4, and wage rates are taken from Table A-5.

TABLE A-10

Annual Labor Costs for Cooler, Dock, Maintenance and Yard Personnel

Operation	Output per hour, in number of head							
	17[a]	20[b]	35[c]	40	50[d]	60	75	120
Cooler and dock:								
Cooler men	3	4	4	5	6	8	8	12
Wage	6,274	6,274	6,274	6,274	6,274	6,274	6,274	6,274
Dock foreman	1	1	1	1	1	1	1	1
Wage	7,397	7,397	7,397	7,397	7,397	7,397	7,397	7,397
Order clerk	--[e]	--	2	2	2	2	2	2
Wage			6,188	6,188	6,188	6,188	6,188	6,188
Dock checker	--	--	1	1	1	1	1	2
Wage			6,274	6,274	6,274	6,274	6,274	6,274
TOTAL ANNUAL COST	26,219	32,493	51,143	57,417	63,691	76,239	76,239	107,609
Maintenance:								
Maintenance men	1	1	2	4	4	5	6	9
Wage	7,311	7,311	7,311	7,311	7,311	7,311	7,311	7,311
Gang leader	--	1	1	--	--	--	--	--
Wage		7,570	7,570					
Foreman	--	--	--	1	1	1	1	1
Wage				8,088	8,088	8,088	8,088	8,088
TOTAL ANNUAL COST	7,311	14,881	22,192	37,332	37,332	44,643	51,954	73,887
Yardmen:	1	1	1	2	2	2	2	3
Wage:	5,842	5,842	5,842	5,842	5,842	5,842	5,842	5,842
TOTAL ANNUAL COST	5,842	5,842	5,842	11,684	11,684	11,684	11,684	17,526

[a] Requirements for these operations in a plant killing 10 head per hour are the same except in the cooler, where 2 men are used. Cooler and dock costs in this case are $19,686.

[b] For a kill of 25 head per hour, an order clerk is added to the dock crew making cooler and dock costs equal to $38,681. All other operations and costs are the same as for 20 head per hour.

[c] For a kill of 30 head per hour, one less order clerk is used reducing costs to $44,955 for cooler and dock personnel. All other job requirements and costs are the same.

[d] Costs and labor requirements to kill 45 head per hour are identical to those for 50 head hourly.

[e] Dashes indicate the position is not utilized as specified.

Source: Labor requirements are taken from Table 5, and wage rates are taken from Table A-5.

TABLE A-11

Annual Labor Costs for Clean-Up Personnel

Operation	Output per hour, in number of head							
	17	20	35	40	50	60	75	120
	number							
Clean-up workers:								
One-bed	1	--[a]	--	--	--	--	--	--
Two-bed	2	2	2	--	--	--	--	--
Three-bed	--	--	3	3	3	--	--	--
On-the-rail	1	1	2	2	3	3	4	5[b]
	dollars							
Total daily cost[c]:								
One-bed	19.76	--	--	--	--	--	--	--
Two-bed	39.52	39.52	39.52	--	--	--	--	--
Three-bed	--	--	59.28	59.28	59.28	--	--	--
On-the-rail	19.76	19.76	39.52	39.52	59.28	59.28	79.04	98.40
Total annual cost:								
One-bed	5,777.00	--	--	--	--	--	--	--
Two-bed	11,554.00	11,554.00	11,554.00	--	--	--	--	--
Three-bed	--	--	17,331.00	17,331.00	17,331.00	--	--	--
On-the-rail	5,777.00	5,777.00	11,554.00	11,554.00	17,331.00	17,331.00	23,108.00	28,885.00

a/ Dashes indicate the position is not utilized as specified.

b/ Includes full-time man working in the basement eight hours at regular pay.

c/ Assumes 4 hours of work after 6:00 p.m. with premium of $0.10 per hour.

Source: Labor requirements are taken from Table 5, and wage rates are taken from Table A-5.

TABLE A-12

Annual Cost of Salaried Personnel for Slaughter Plants with Various Rates of Output

Operation	Annual cost per worker dollars	Number of workers for plants with hourly cattle kill rates of							
		17	20	35	40	50	60	75	120
Office:									
Switchboard	5,200	--[a]	--	--	1	1	1	1	1
Payroll, accounts payable	7,540	--	1	1	1	1	1	1	2
General	6,500	--	--	--	1	1	1	1	3
Credit manager, livestock payable	9,100	--	--	--	1	1	1	1	2
General ledger, office manager	10,400	--	--	--	1	1	1	1	2
Phone, billing, posting	5,200	1	1	2	--	1	2	2	3
General ledger, credit, accounts payable	10,400	1	1	1	--	--	--	--	--
TOTAL ANNUAL COSTS		15,600	23,140	28,340	38,740	43,940	49,140	49,140	94,380
Buying and selling:									
Buyers	10,400	1	1	2	2	3	5	5	7
Sellers	10,400	2	2	3	3	4	5	6	9
TOTAL ANNUAL COST		31,200	31,200	52,000	52,000	72,800	104,000	114,400	166,400
Management:									
General manager[b]	15,000	1	1	1	1	1	1	1	1
Senior buyer [c]	12,000	--	--	1	1	1	1	1	1
Sales manager [d]	12,000	--	--	1	1	1	1	1	1
Plant superintendent [e]	10,400	--	--	--	--	1	1	1	1
Assistant plant superintendent [f]	10,400	--	--	--	--	--	1	1	1
TOTAL ANNUAL COST		15,000	17,500	44,000	54,400	62,900	75,900	75,900	86,000

[a] Dashes indicate the position is not utilized as specified.

[b] Salary rate of general manager is assumed to increase with the size of the plant as follows: 15 head, $15,000; 20 head, $17,500; 35 and 40 head, $20,000; 45, 60, and 75 head, $22,500; and 120 head, $25,000.

[c] Salary rate of senior buyer is assumed to increase with the size of the plant as follows: 35 and 40 head, $12,000; 45, 60, and 75 head, $15,000; and 120 head, $17,000.

[d] Salary rate of sales manager is assumed to increase with the size of plant as follows: 35 and 40 head, $12,000; 45, 60, and 75 head, $15,000; and 120 head, $17,000.

[e] Salary rate of plant superintendent is assumed to increase with the size of the plant as follows: 40 and 45 head, $10,400; 60 and 75 head, $13,000; and 120 head $15,000.

[f] Salary rate of assistant plant superintendent is assumed to increase with the size of plant as follows: 60 and 75 head, $10,400; 120 head, $12,000.

Source: Labor requirements are taken from Table 7. For salary rates, see text.

TABLE A-13

Principal Minimum Distance Requirements[a]

Description	Vertical distance
Bleeding rail (distance from rail to point of application of shackle to shackled foot -- 48")	16' 0"
Dressing rails (trolley length -- 15")	11' 0"
Beef cooler rails (trolley length -- 15")	11' 0"
Rails for beef quarters (trolley length -- 15")	7' 6"
Dry area in front of stunning pen -- Horizontal distance	7' x 8'
Curb of bleeding area to pritch plates	5' 0"
Line of drop-offs to line of half hoists (two-beds)	16' 0"
Line of drop-offs to line of half hoists (three beds or more)	18' 0"
Line of half hoists to header rail loading to cooler (single rail)	10' 0"
Between header rail and carcass washing rail, if parallel	6' 0"
Between header or washing rails and wall of slaughter room	3' 0"
Between center lines of dressing beds	8' 0"
Area for sterilizing viscera inspection truck	7' x 8'
Between moving top table and dressing rail at inspector's platform	5' 6"
From vertical of rails in slaughtering rooms, coolers, etc., to walls, posts, and other fixed parts of building	2' 0"
Width of doors through which carcasses are railed	4' 6"
Width of doors through which product is conveyed in hand trucks	5' 0"

[a] U. S. Inspected Meat Packing Plants, a Guide to Construction, Equipment, Layout, op. cit., p. 38-39.

TABLE A-14

Freight Rates for Shipments to Los Angeles

Shipment from	Rate to Los Angeles per 100 pounds
San Francisco:	
Less than truck load	2.41
4,000 pounds	1.52
10,000 pounds	1.16
20,000 pounds	1.02
24,000 pounds and over	.66
Chicago:	
Less than truck load	6.12
20,000 pounds	4.66
24,000 pounds and over	4.65

Source: Pacific Intermountain Express Company.

TABLE A-15

Equipment Requirements for Synthesized Conventional Slaughter Plants

Swivel chairs	10	6.0	--	12.0		15.0	
Steno chairs	10	1.0	--	2.0		2.0	
Straight chairs	10	7.0	--	14.0		17.0	
Desk calculator	10	2.0	--	4.0		5.0	
Checkwriter	10	1.0	--	1.0		1.0	
Drinking fountain, bottle	10	1.0	--	1.0		1.0	
Safe	10	1.0	--	1.0		1.0	
Time clock and card rack	10	1.0	--	1.0		2.0	
Typing stand with casters	10	2.0	--	4.0		6.0	
Intercommunications system	10	1.0	--	1.0		1.0	
Offal hanger, 51 hooks	5	2.0	55.00	.0		.0	

a/ Dashes indicate the item may be purchased locally, hence freight is not a cost factor.

b/ Unless otherwise indicated, the per unit weights in these columns are the same as for the one-bed plant.

c/ Sizes are 18" x 18" for one-bed plant, 24" x 24" for two-bed and three-bed plants.

d/ Hand scribe saws are used in one-bed and two-bed plants and an air powered saw is used in the three-bed plant.

e/ Platform is hydraulic lift type for one-bed plant, stationary for two-bed and three-bed plants.

f/ Platform is hydraulic lift type for one-bed and two-bed plants, stationary for three-bed plants.

g/ Shroud tank is 18" x 30" x 30" for one-bed and two-bed plants, 24" x 36" x 36" for the three-bed plant.

h/ Live animal scale is 14' x 8' for one-bed plant, 22' x 8' for two-bed and three-bed plants.

i/ Pressure pump is multi-stage electric drive with capacity of 20 gallons per minute for one-bed plants, 40 gallons per minute for two-bed plant and 60 gallons per minute for the three-bed plant.

j/ Solids pump has capacity of 300 gallons per minute with 3" maximum size of solid for one-bed, two-bed, and three-bed plants.

k/ Boiler is 20 horsepower for one-bed plant, 35 horsepower for two-bed plant, 45 horsepower for three-bed plants.

l/ Blood tank capacity is 840 gallons for one-bed plant, 840 gallons for two-bed plant, 1,000 gallons for three-bed plant.

m/ Head work-up table is 8' for one-bed and two-bed plants.

n/ Offal table is 2-1/2' x 5' for one-bed plant, 3-1/2' x 5' for two-bed plant, 3-1/2' x 6-1/2' for three-bed plant.

Source: Quantities and weights were derived from manufacturing data on capacity and poundage, and from accounting records of the seven California plants studied in detail. Estimated use life was estimated from accounting records.

TABLE A-16

Equipment Requirements for Synthesized On-The-Rail Plants

Equipment	Estimated use life	On-the-rail plants									
		A		B		C		D		E	
		Quantity	Weight per unit	Quantity	Weight per unit	Quantity	Weight per unit	Quantity	Weight per unit	Quantity	Weight per unit
	years	number	pounds	number	pounds	number	pounds	number	pounds	number	pounds
Single shot .22 rifle	1	1	a/	1		2		2.0		4	
Knocking pen door (revolving)	10	1	1,700.00	1	b/	2		2.0		4	
End gate for knocking pen	10	1		1		2		2.0		4	
Electric beef hoist (7.5hp) with automatic lander	20	1	660.00	1		2		2.0		4	
Blood and water drain	20	1	75.00	1		2		2.0		2	
Bleeding rail, tracking, hanger	20	1 lot	527.00	1 lot	767	1 lot	2,273.0	1.0 lot	1,051.0	--	
Shackle lowerator	20	1	800.00	1		1		1.0		1	
Overhead bleeding conveyor system	20	0		0		0		0		1	7,054.0
Electric beef hoist(bleeding rail to dressing rail .5hp)	20	1	620.00	1		1		1.0		2	
Powered cattle rail system	20	1	9,980.00	1	11,565	1	16,230.0	1.0	16,214.0	1	13,505.0c/
Brisket saw	15	1	100.00	1		1		1.0		1	
Carcass splitting saw	15	1	175.00	1		1		1.0		2	
Air powered dehiders	15	7	15.00	7		10		10.0		20	
Air pressure regulators, filter for dehiders	10	7		7		12		10.0		20	
Air shin bone saws	15	2	100.00	2		2		2.0		4	
Head flushing cabinet 36" x 36"	20	1	275.00	1		1		1.0		0	
Head flushing cabinet 48" diameter	20	0		0		0		0		1	500.0
Head rinse cabinet, 48" diameter	20	0		0		0		0		1	300.0
Head and tongue conveyor system	20	0		0		1	4,883.0	1.0	5,511.0	1	6,720.0
Inclined screw conveyor system	10	0		0		0		0		1	1,200.0
Udder conveyor system	20	0		0		0		0		1	1,000.0
Saw sterilizers	10	2	135.00	2		2		2.0		3	
Head work table d/	20	1	350.00	1	425	1	425.0	1.0	818.0	1	2,268.0
Pneumatic head splitter	15	1	800.00	1		1	4,200.0	1.0	4,200.0	1	4,200.0
Offal washing table e/	20	1	240.00	1	240	1	480.0	1.0	493.0	1	1,150.0
Work platforms	20	1 lot	887.00	1 lot	915	1 lot	7,110.0	1.0 lot	7,999.0	1 lot	28,838.0
Wash and shroud platforms	20	1 lot	520.00	1 lot	1,440	1 lot	1,800.0	1.0 lot	1,800.0	1 lot	5,130.0
Tracking, hangers, switches	20	1 lot	978.00	1 lot	441	1 lot	1,786.0	1.0 lot	1,786.0	--	
Beef shackles	10	10	22.50	16		25		25.0		50	
Beef trolleys	10	1,500	7.00	2,400		3,600		4,496.0		7,200	
Cattle head trucks f/	10	2	260.00	2		0		0		0	
Tripe inspection ring -- 12 hook	10	0		0		2	50.0	2.0		3	
Paunch trucks -- stainless	10	2	225.00	3		0		0		0	
Liver trucks -- 60 hooks	10	2	320.00	2		1		1.0		0	
Tripe inspection trucks with pan	10	2	300.00	2		0		0		0	
Lavatories, knife sterilizers with drinking attachments	10	5	104.00	8		15		15.0		30	
Paunch table, stainless top	20	1	2,500.00	1		1		1.0		1	3,788.0
Air hoist for above table	10	1	475.00	1		0		0		0	
Moving top viscera inspection table g/	15	0		0		1	24,000.0	1.0	28,800.0	1	39,900.0

TABLE A-17

Daily Kill, Blood Production and Specified Size of Blood Tank for Synthesized Plants

Daily kill	Blood output	Blood tank capacity
number of head	gallons	
112 (one-bed)	711.2	840
262 (two-bed)	1,467.2	840a/
337 (three-bed)	2,100.0	1,000a/
150 A	840.0	840
300 B	1,680.0	840a/
450 C	2,520.0	1,500a/
562 D	3,147.2	2,000a/
900 E	5,040.0	2,000b/

a/ Empty twice a day.

b/ Empty three times a day.